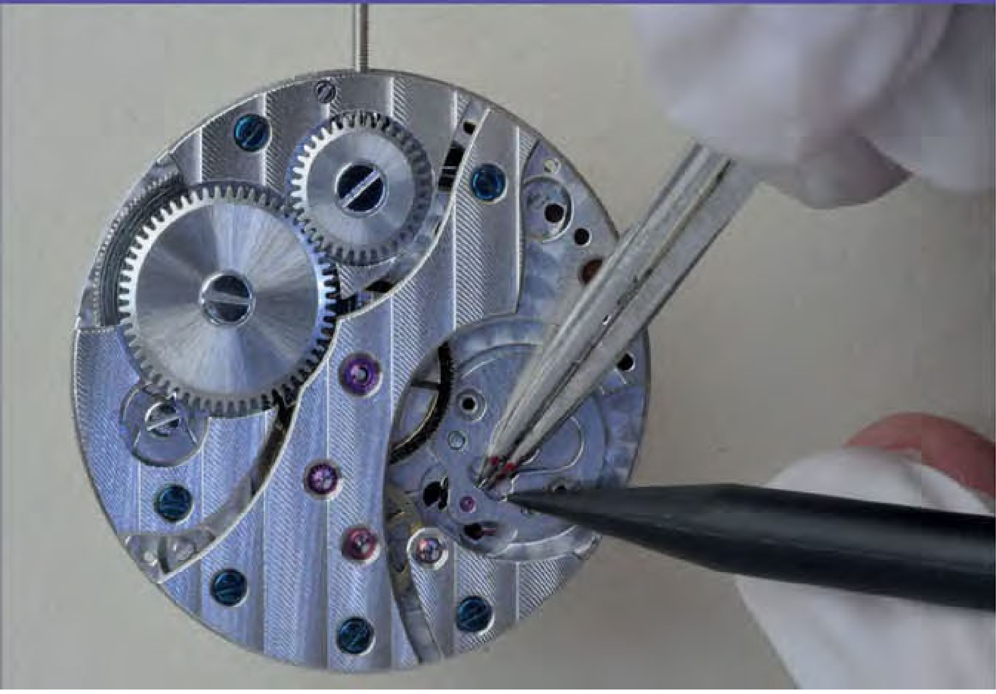
MAINTAINING AND REPAIRING Mechanical Watches

A Practical Guide

Mark W. Wiles



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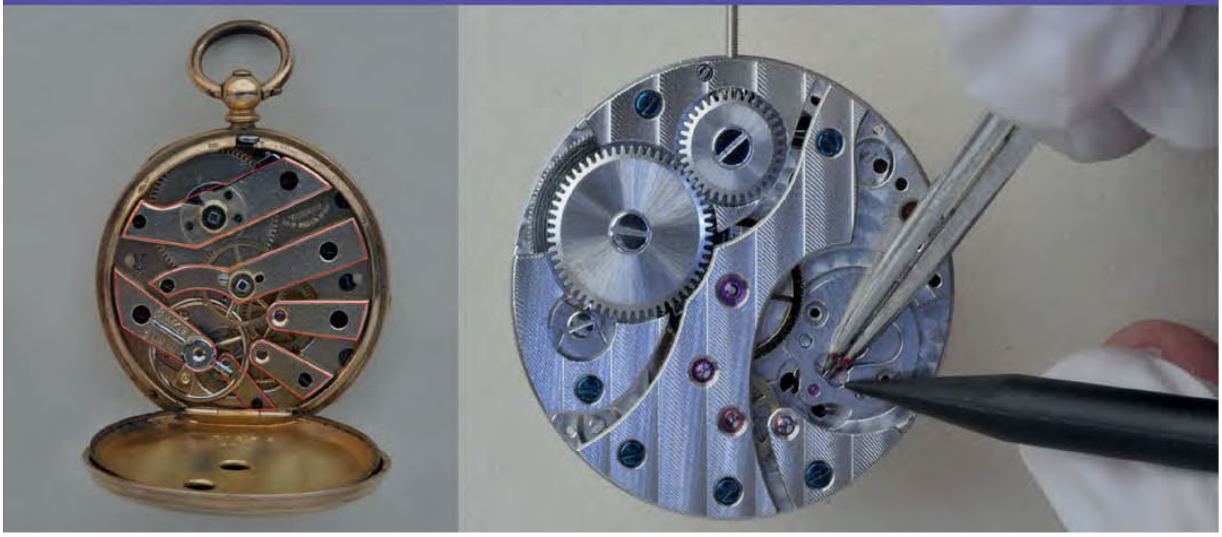

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INTRODUCTION

This book has been written with the complete novice in mind, and will guide the reader step by step through each page, learning about the theory behind how a watch works as it is taken to pieces. You will learn how to take each watch apart and, possibly more importantly, how to put it back together again without damaging it. You should think of this as a hands-on voyage of discovery. As your skill and confidence grow, the tasks that you will undertake will also increase in technical ability, thus improving your finger dexterity and skill.

There are many old wives' tales as to why not to undertake watch repairing; some are given below, with reasons as to why they are unfounded.

You need sharp eyesight: Watchmakers use an eyeglass at all times, and you soon become comfortable with wearing one for long hours, working in a small world no bigger than a beer mat. It's no different to wearing glasses – and if you wear glasses it's still not a problem.

You need steady hands: Steady hands are not a necessity either, because if your bench and chair are at the right height your hands are rested and supported on the bench, which will stop them from shaking.

You need patience: When I started I had no patience at all, and rushed everything. However, as with most things, age (and making many mistakes) increases your patience. I find I have patience in abundance now, as I am sure you will too.

Fat fingers: Fat fingers are certainly not a problem, as watch components should never be touched with the fingers. In this world your 'fingers' will be a pair of tweezers.

You need to be young: I know people in their seventies and older who repair and even make watches.

I certainly believe that it is possible for anyone to take a watch to bits, clean it, and put it back together and have it working to some degree with a small amount of help. The real test of skill and ability comes with the problem-solving skills of diagnosing faults, which requires a mechanically minded person. This in itself is very hard to pick up and learn, generally coming naturally to some people, who will have a distinct advantage in this process.

If you are not this type of person, then you may have to work twice as hard, and you will be even more frustrated when things don't work as they should. I would recommend trying to find a 'tame' watchmaker to help you out on the occasional day you get really stuck. But a word of warning: such watchmakers don't grow on trees, and if you find one, only use them in absolute desperation, because they are a busy lot and will soon tire of someone bringing nothing but problems! Usually watchmakers are keen to help, and can be chatty, but remember that their job is demanding, so don't keep them away from their bench for too long.

At the time this book is being written the watch trade is in somewhat of a renaissance, with the luxury watch brands on a drive to make more mechanical watches now than they were in the sixties, but unfortunately there is a real shortage of watch repairers in the industry. So if you are looking for a new and rewarding career you are certainly on the right path by reading this book. Alternatively, if you are looking for a hobby in repairing or collecting watches and restoring them yourself, the rewards can be just as great. It is most certainly up to you how far you take it.

It's just a small matter of time.

PART I: THE BASICS

1. BASIC TOOL KIT

The items described in this section make up the most basic tool kit that you will need just to take a watch to pieces and put it back together again. I will focus on cleaning watches once we have covered the basics. The main reason for doing this is to make sure you feel comfortable working with watches before you rush out and buy a complete workshop. As we work through the book I will introduce you to more tools and the processes involved in using them.

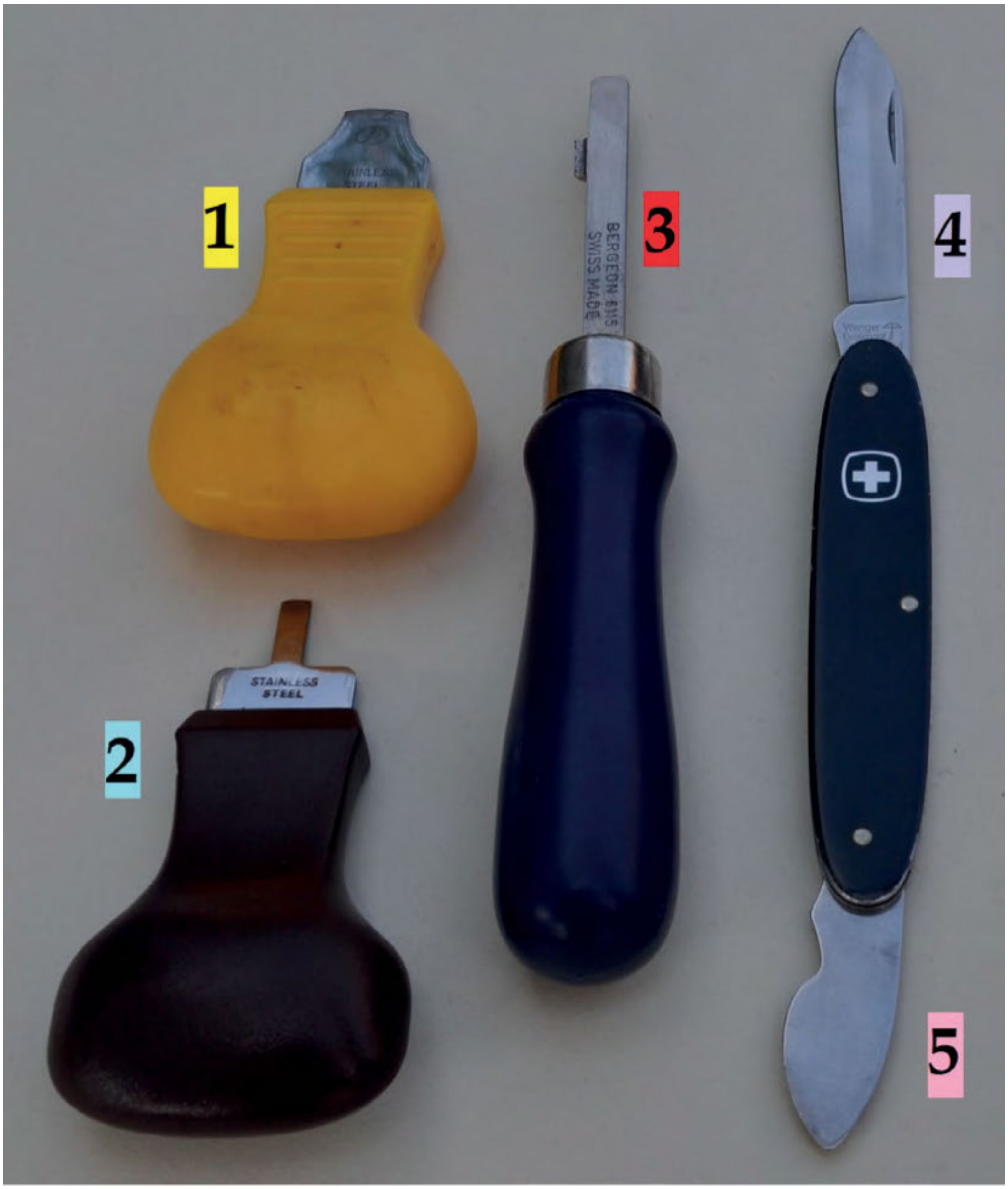
BUYING YOUR TOOLS

My dear dad, as a self-employed mechanic, would always procure the cheapest tools that he could at markets and boot sales in order to try and save a penny. This was also the way I approached my hobby as a twelve-year-old, and I would always first seek out a cheaper alternative – but I soon found out, as did my dad on a number of occasions, that sometimes it is better to spend that little extra and buy the best you can afford from a reputable dealer when you start out.

This might seem obvious, but I have seen many a student like myself fall into the same trap. We all think we know better and buy the cheaper one, only to find that it doesn't last, or fails to do the job as satisfactorily as we would like. Cheaper tools are no substitute for ones of quality. But if you are not sure if watch repairing is for you, and are just intrigued at this point, then maybe it would be better to take the cheaper route at this point.

Bench Mat

You can use a craft cutting mat, found in hobby shops – 12 x 8in (30 x 20cm) in size – or the traditional watchmaker's green plastic or rubber mat, normally made by Bergeon or the cheaper 'A & F' (Albert Froidevaux & Fils).This will provide a hard-wearing, easy-to-clean work surface. They are normally a pale green but also come in black and grey. The colour is important: you need one that is calming and easy on the eyes, as you will be spending long periods looking at it. I personally prefer the anti-static watchmaker's mat for its price, and I like the softer feel of the mat for those long nights at the bench. I also find with the harder mats that the corners tend to roll up because the glue dries out quite quickly, and the more you restick them the uglier they look and the more they tend to roll up in other places. Craft mats are much better and cheaper as part of a hobby. If money isn't a problem, then opt for the soft anti-static bench mats.



Case Knife

Fig. 1: Images 1 and 2 show Japanese-style case openers. Image 3 is a case opener used to open square or rectangular case backs. Image 4 is the traditional case knife. 5 The blade used to open watch cases.

This is similar to a penknife, with the addition of the smaller blade that has been specially shaped to open watch cases. The blade is not razor sharp like a normal blade, and is very slightly rounded and polished. For now, if you have a penknife, you could modify the smaller blade by rubbing the sharp edge with a knife sharpener to just lightly polish its cutting surface. It is very important that a blade of this type is used when opening a watch case, as sometimes great force is necessary to open a stubborn watch back. However, on occasions cases can open up more quickly than expected and the knife can slip into your fingers or damage the case. Hence, a blunted knife edge will greatly reduce the risk of damage either to you or the case.

The other types of case opener are shown in the photograph: in the first two images are Japanese tools used by Citizen and Seiko; these have the advantage in that you can apply more pressure to the blade as they are designed to be pushed with the palm of your hand instead of your fingers. The third image shows a tool used to open oblong watches as the lifting point is normally between the lugs.

Jaxor-Type Case Opener

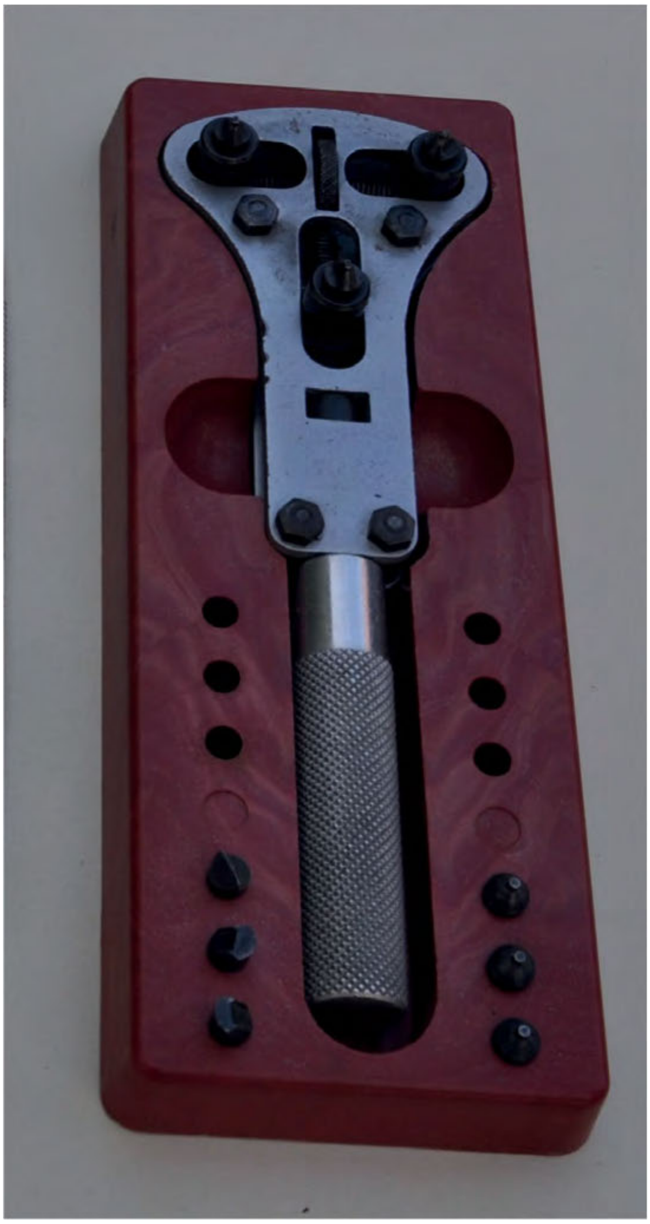
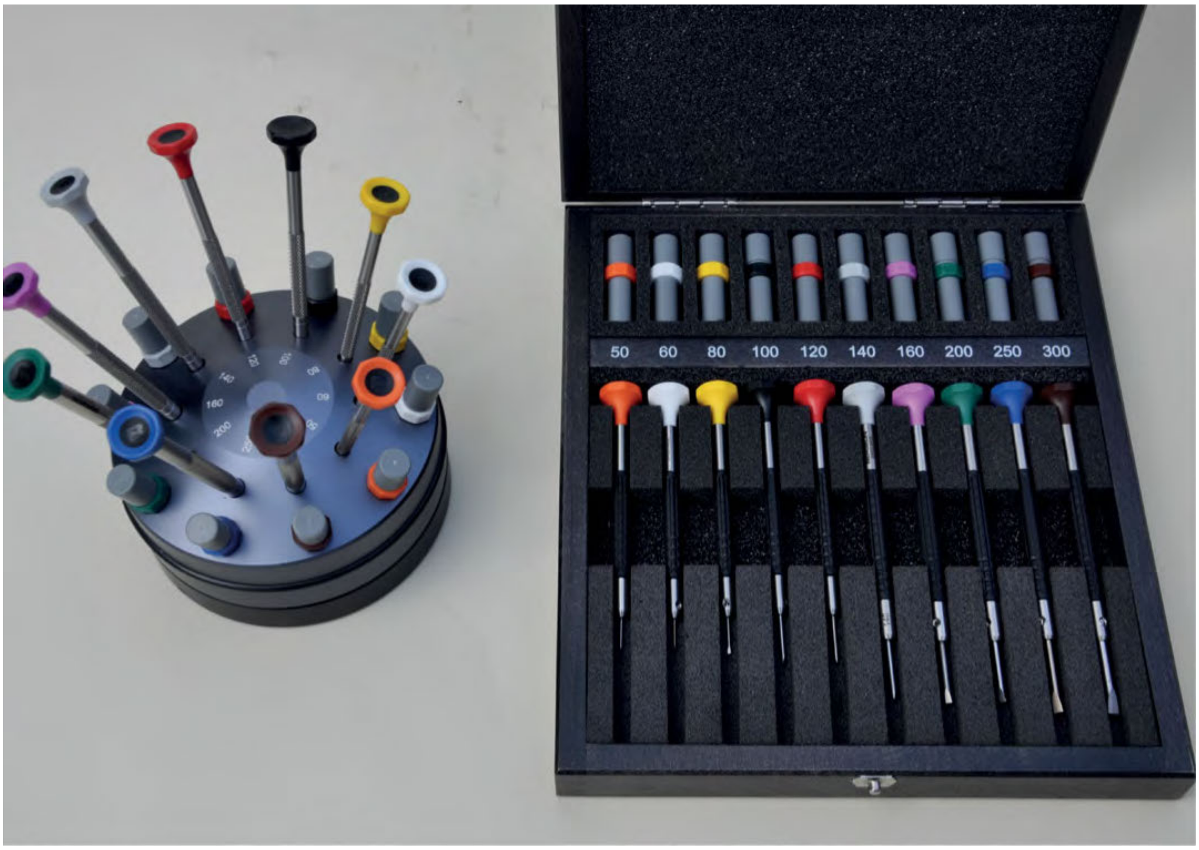


Fig. 2: Jaxor tool.

This is a sort of adjustable spanner for unscrewing the backs of watch cases. The Jaxor tool has three pins which can be adjusted to fit many types of watch case on the market. The better quality one is made by Jaxor or Bergeon, but if you are on a budget, the Chinese make one that is very similar and cheaper; however, the quality isn't as good, and the tool's lifespan will be shorter as the steel inserts are made from poor quality steel.



Watchmaker’s Screwdrivers

Fig. 3: Watchmaker’s screwdrivers.

I would recommend the type with removable blades and swivel tops, normally seen in a grey or chrome carousel stand or sometimes found in a neat wooden box. I would not use the type more commonly seen in most tool stores, in either a blue or black plastic box with a see-through lid, as the steel quality is very poor. This type of blade chips very easily and gnarls up the screws, leaving you with the predicament of a screw that you cannot extract. Also you cannot replace the blades, giving them a short lifespan. A good starter screwdriver is made by A & F, with their nine-piece stainless-steel screwdrivers in a carousel stand.

Bergeron 7010 Component Probe

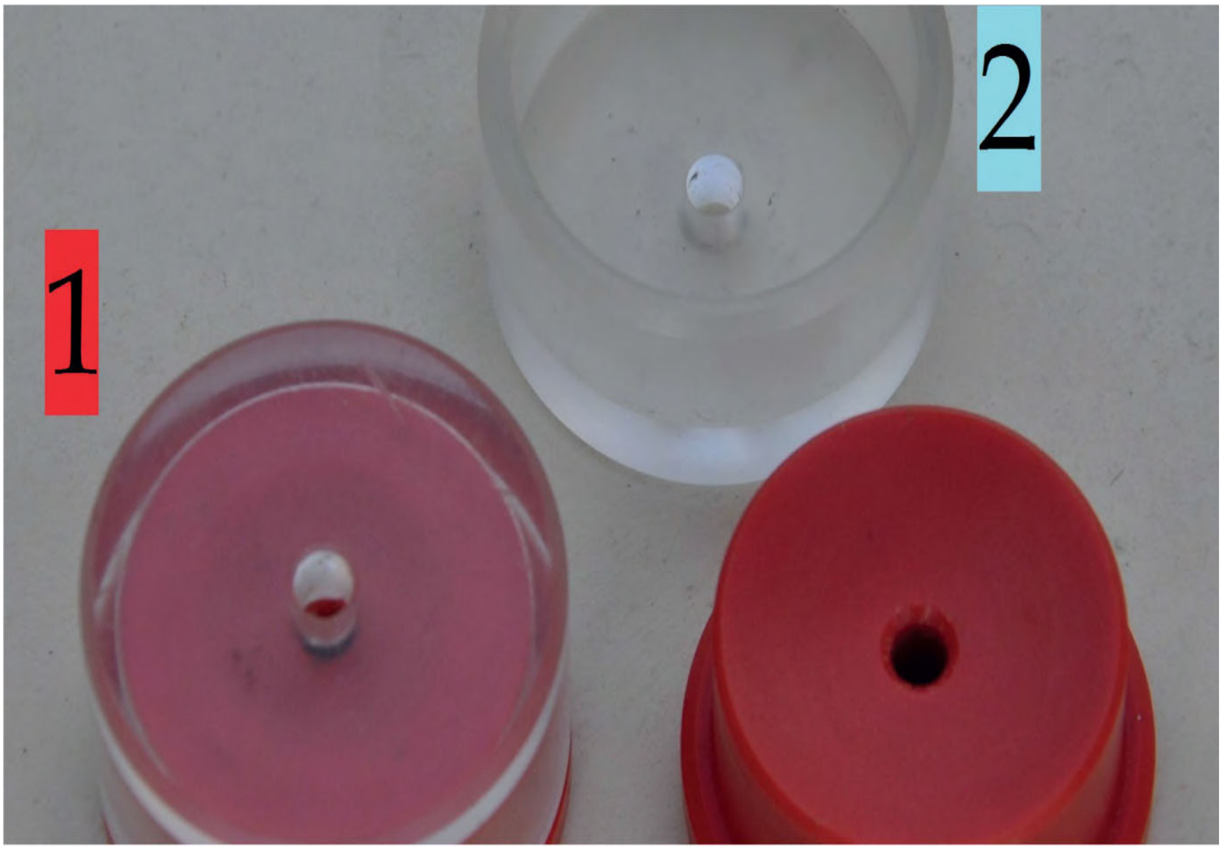


Fig. 4: Watch probes. 1 Homemade probe; 2 Bergeon 7010 Probe.

This probe is used to help hold components still during assembly. Alternatively, you can make your own version using a piece of 5mm peg wood. To make a home-made probe, sharpen one end of the peg wood like a screwdriver and the other like a spear, with a long gradual taper. Dip both of the shaped ends into some enamel paint: this will seal the wood to keep it clean and stop it soaking up any oil.

Eye Glasses

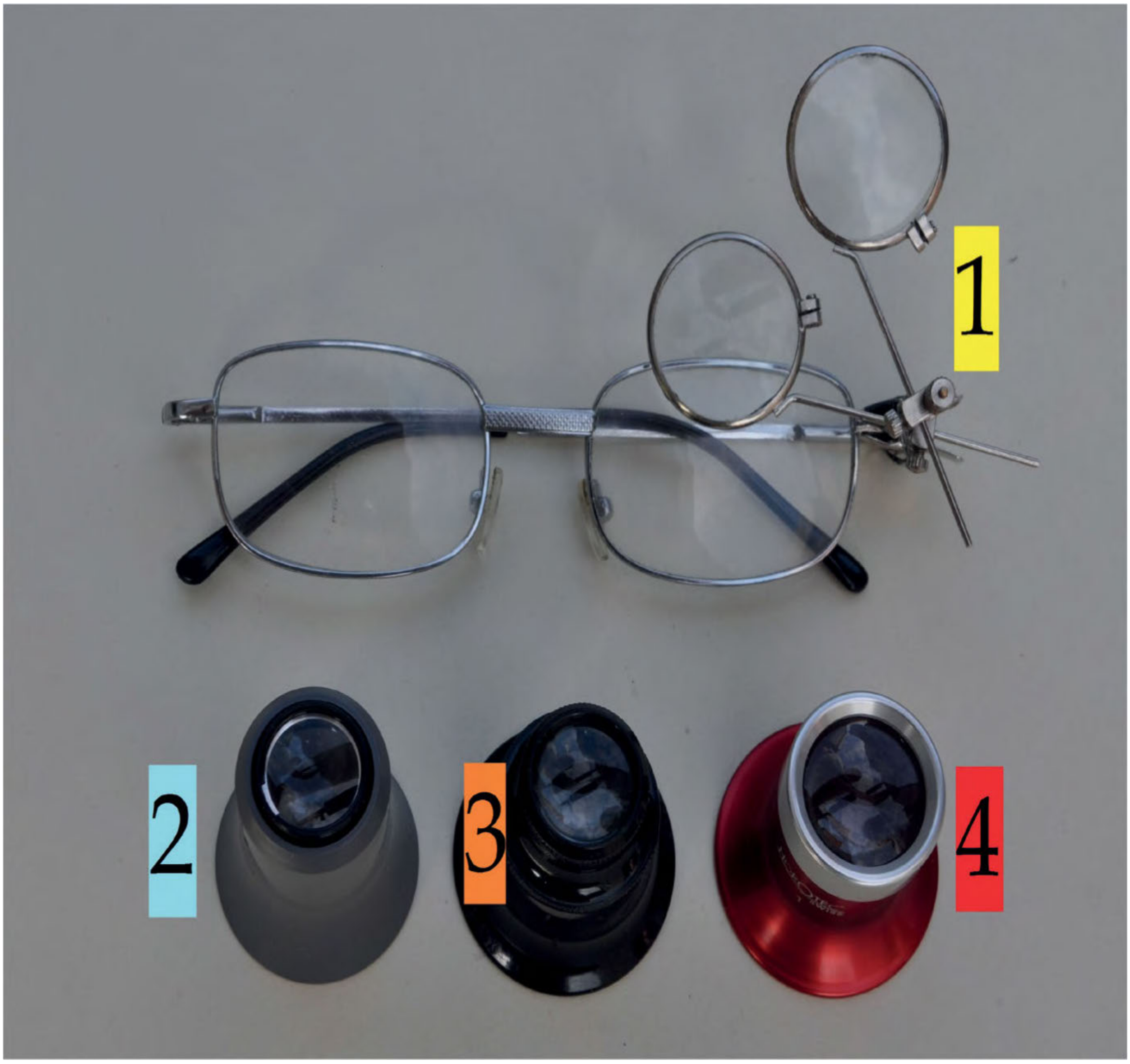


Fig. 5: Watch repairer's eye glasses. 1 Clip-on eyeglass; 2/3 High magnification eyeglasses; 4 Typical jobbing eyeglass.

Image 4 in Fig 5 shows the most common type of watch repairer's eye glass. I personally use a 3x for most of my work, but this is something you might have to experiment with until you find the lenses that work best for you. I first bought the cheaper Bergeon plastic eye glasses of varying magnification, until I found one that I liked. A few years later I decided to buy a more upmarket Horotec eye glass, but I soon found that there seems to be no real standardization regarding magnification, as there was a definite difference in strength between the Bergeon and the

Horotec. This problem was soon solved, however, as the lenses from the Bergeon swapped over with the one from the Horotec, to make a much more comfortable eye glass.

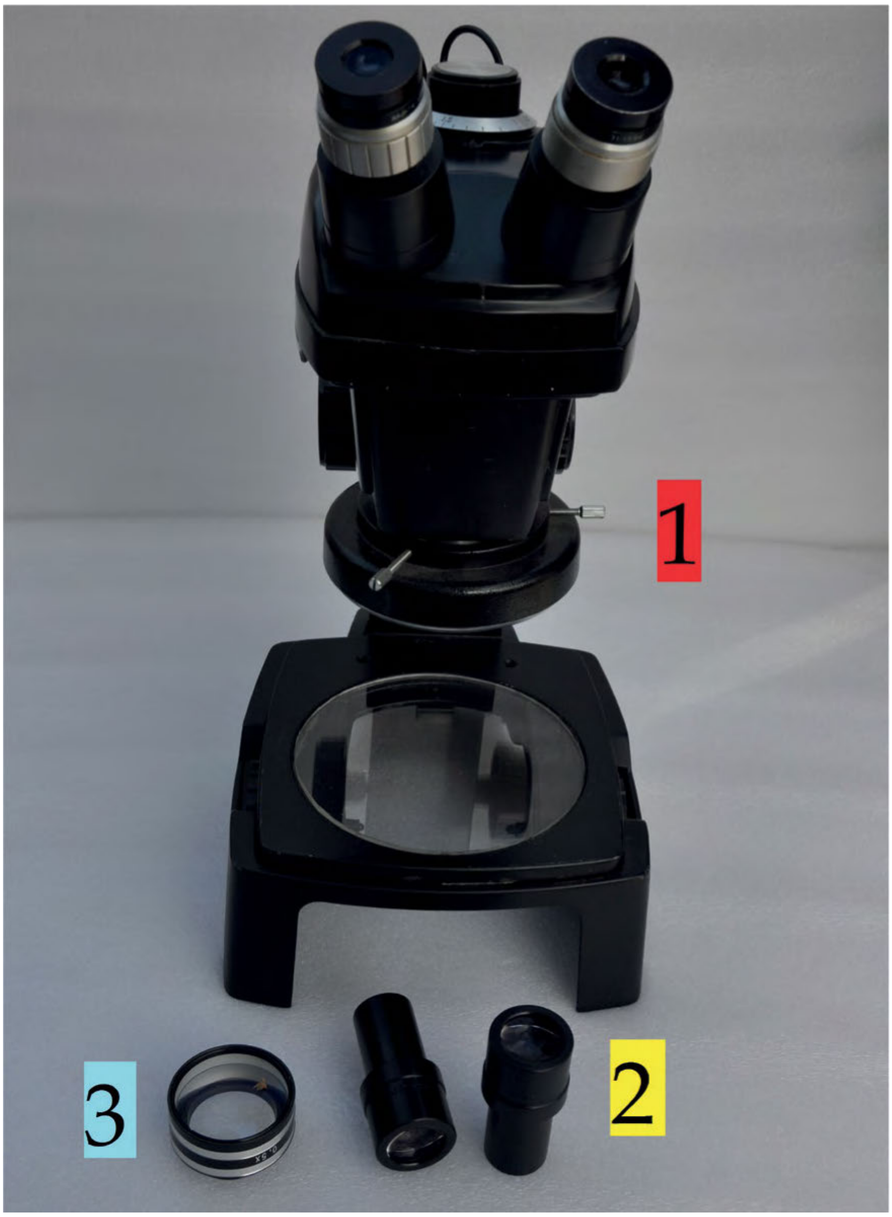
Using a different strength glass felt like using someone else's glasses prescription. I would definitely recommend getting a 12x for close-up inspection. If you find you struggle to hold an eye glass in, this may be due to the type you have bought. Again, the body of an eye glass also seems to vary in size, so you will have to try before you buy. And if you still struggle to hold in an eye glass you could opt for an eye-glass holder. There are two types: the first is a loop of string that wraps round your head and holds the glass in place. This can be made using some piano wire, or you can buy one from a tool dealer. The second looks like a pair of reading glasses with no lenses, and the eye glass clips on to the frame.

Many people struggle to hold in an eye glass, and this is mainly due to genetics! If you haven't got chubby cheeks or high cheek bones to hold in your eye glass, this will always be a problem. If you think this will be an issue, then buy a plastic eye glass or one that has a metal rim round the lenses. I soon found that when I dropped any plastic eye glasses on the floor the rim that secures the lens in place inevitably cracked in half, so I would highly recommend the ones with the metal rim. After replacing several over the years, I opted for the more expensive Horotec eye glass, with a plastic body and a red anodized rim to hold the lens in. I have had this one for four years to date, and I have dropped it many times and it hasn't broken.

Note that metal eye glasses tend to be a little heavier than plastic ones, and are prone to falling out of your eye and dropping on to the watch you are working on, especially on a hot day if your face becomes sweaty. If you are one of those lucky people who wear glasses you can purchase an eye glass that will clip on to your frames (don't wear your smart frames, as some clip-on eye glasses may mark them).

If you find that things are too small and/or are out of focus, then you can use some sort of headgear or a microscope. This is very much a personal choice. To start off with, it may be advisable to buy a cheap glass and then just experiment with different types. If you plan this as a career, it is worth noting that all professional watchmakers use an eye glass for the majority of their work. However, if you are thinking of watchmaking as a hobby and an eye glass doesn't seem to work for you, I would recommend the use of helmet-type binoculars, sergeant's glasses, or even a stereo microscope with a halving lens and ring light. These will give you a much larger working area. I recommend asking if you can 'try before you buy' if at all possible.

Tip: It's a good idea to drill two or three large holes in the frame of your eye glass, as prolonged use of an eye glass causes fogging. It's also a good idea to rest your eyes for a few minutes after half an hour's constant use. Avoid using a very strong eye glass for a long period of time, as this can certainly lead to headaches and eye strain.



Microscope

Fig. 6: 1 Bausch and Lomb microscope; 2 10X wide field lenses; 3 halving lens.

The microscope most favoured by my fellow watchmakers is the Bausch & Lomb stereo zoom 0.7x–3x magnification. It is quite an old microscope and can be picked up reasonably cheaply. Most of the microscopes I have seen in the trade are either on a traditional stand or some form of boom stand to give you a large, unhindered working space.

The accessories you will need to look out for are a pair of 10x-wide field magnification eye pieces, with an additional 0.5x halving lens; this will give you a maximum of 15x or 30x magnification without the halving lens. The halving lens will give you a much larger working space of 4 to 7in (10 to 18cm), but as the name suggests, will halve the magnification.

You should then attach a ring light to the halving lenses to provide a down light to illuminate the watch that you will be working on.

Microscopes are very useful to have in a workshop – for example, a high magnification is needed when inspecting parts on small watch movements to determine their condition, or when working on tuning folk transistor watches such as the Bulova Accuton. The latter would require 60x magnification with wide field eye lenses, and a light box positioned under the movement to provide light underneath as well as above it so you can see clearly though the inspection holes. (This will probably not be required quite yet, but it is certainly something to put on Santa’s shopping list in the future.)

Tweezers

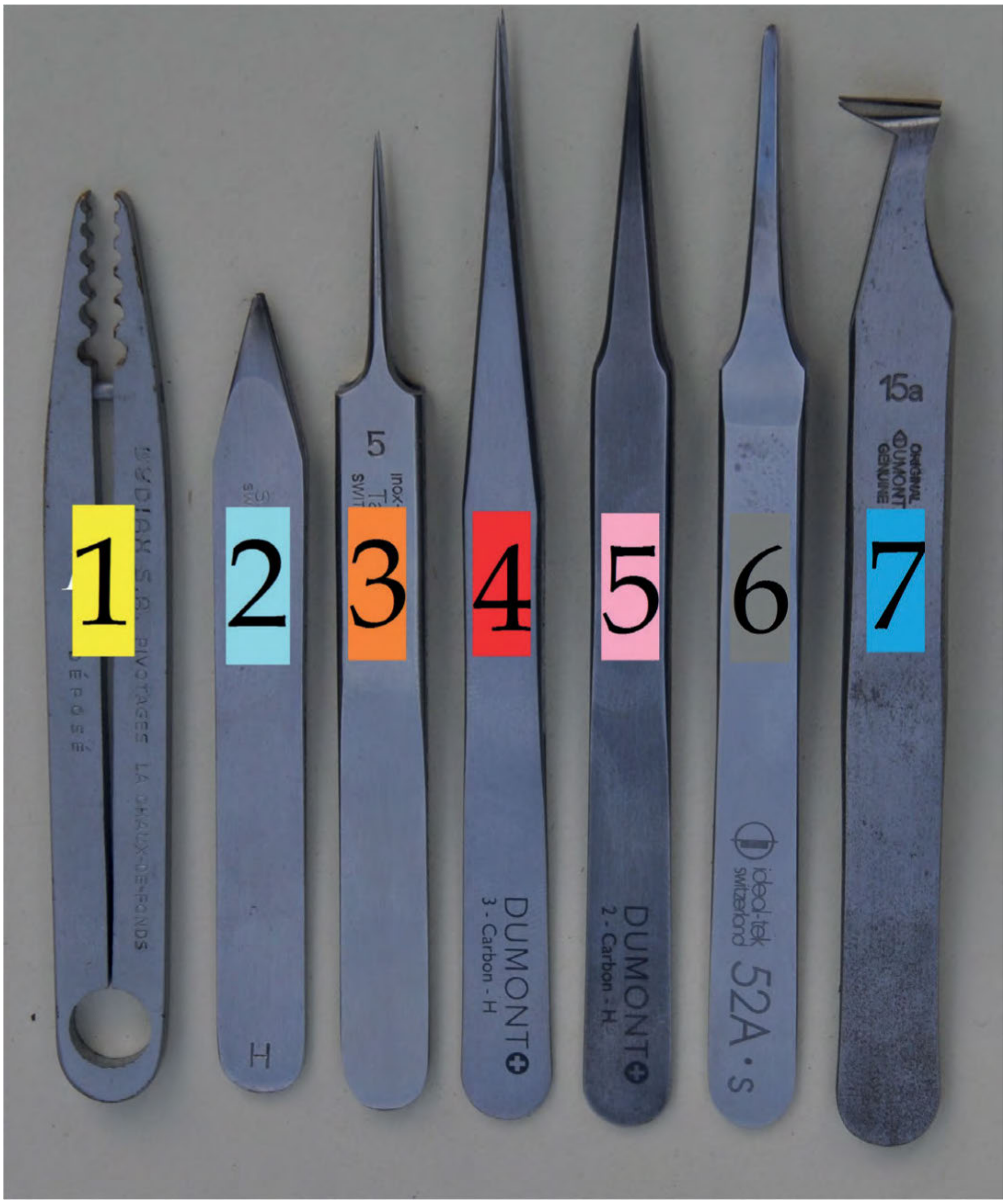


Fig. 7: A selection of tweezers that might be found on a watch repairer's bench: 1 Used for adjusting rollers on the balance wheel. 2 Heavy-duty working tweezers, great for straightening the tips of your tweezers; originally made to remove the springs from Fixoflex expanding watchstraps. 3 No. 5, balance spring tweezers. 4 No. 3, used for fine work and for adjusting larger balance springs. 5 No. 2, used for everyday work. 6 52A or F tweezers, used to adjust the levelness of watch hands. 7 15a Cutting tweezers used to cut brass taper pins.

Choose No. 2 or No. 3 Dumont or their equivalent. There are many brands and types of metal to choose from. If you can afford it, I would recommend the non-magnetic and rust-proof variety, as there is nothing more annoying than a magnetized screw sticking to your tweezers, or working with rusty tweezers. The more expensive types are made from titanium or stainless steel, and therefore neither rust nor become easily magnetized. For a good start Vitus ST 10 or No. 3 are just about adequate.

I would highly recommend the No. 2 Dumont in carbon steel to start with, as they are best for beginners. They are quite broad tipped and will take a lot more punishment than the No. 3 Dumont. In my professional capacity I use No. 3s, but they have been sharpened a lot over the years and are now probably closer to No.2s. When I was at college I did have a pair of No. 2s, but I stopped using them as they were the cheaper steel type and were always rusty, and I got tired of cleaning them. What I will say in defence of carbon steel tweezers is that they are less likely to become bent with use, and I now use these every day. (It is worth noting that when I was younger, my hands were a lot moister, and steel tweezers would be covered with rust by the end of a week's use.)

You should also purchase a pair of brass tweezers for handling soft metal parts such as hands and jewels. These are favoured by the Swiss, but bend much more easily, so will need to be maintained more regularly.

There are many different types of tweezer on the market, and many of them are for specialized jobs. In time you will be able to determine if you require more variation in the types of tweezer you have, but for now just keep the basics. I like to have everything, so I know it's hard to resist just rushing out and buying every tool in the shop.

Pin Vice

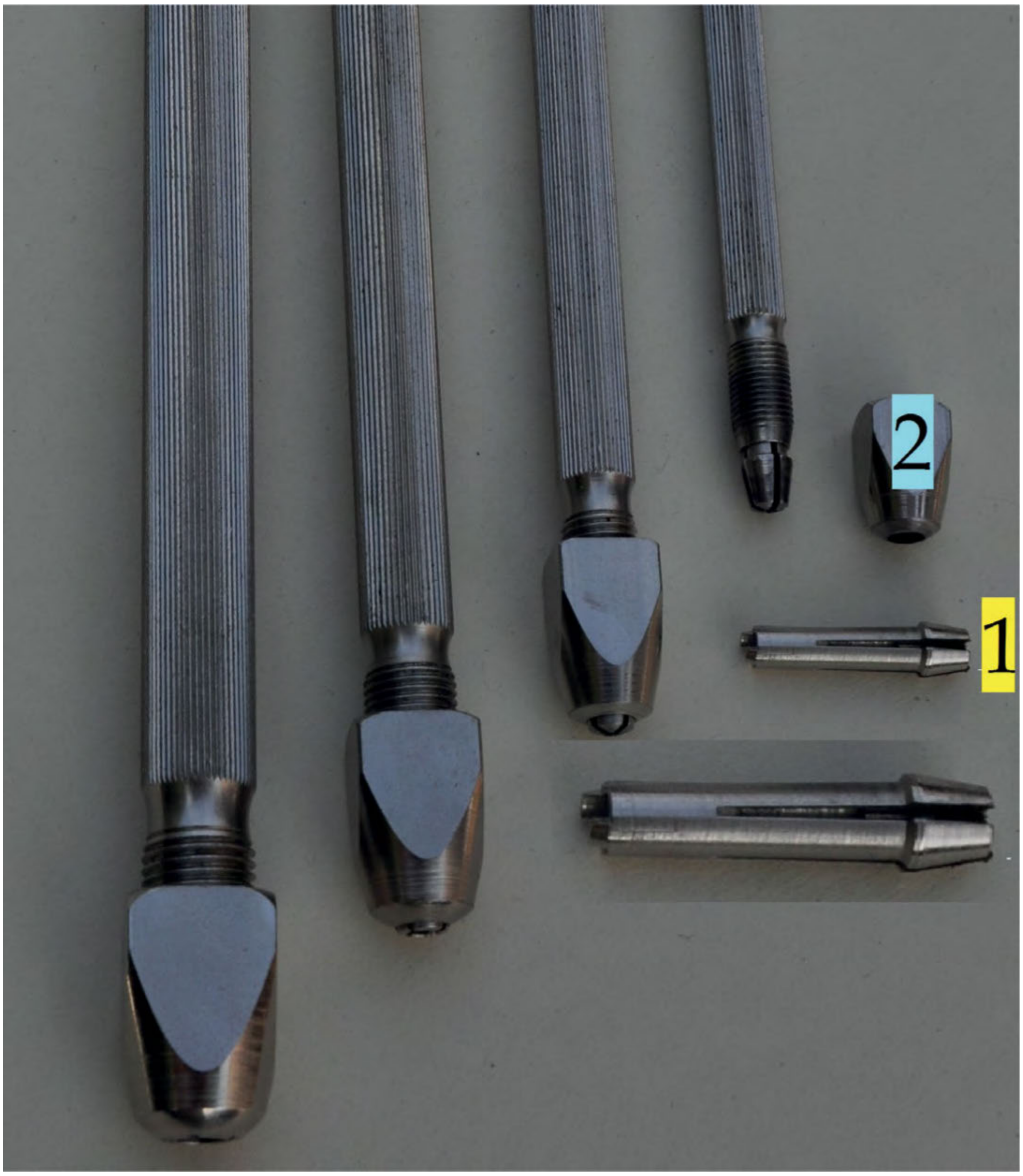
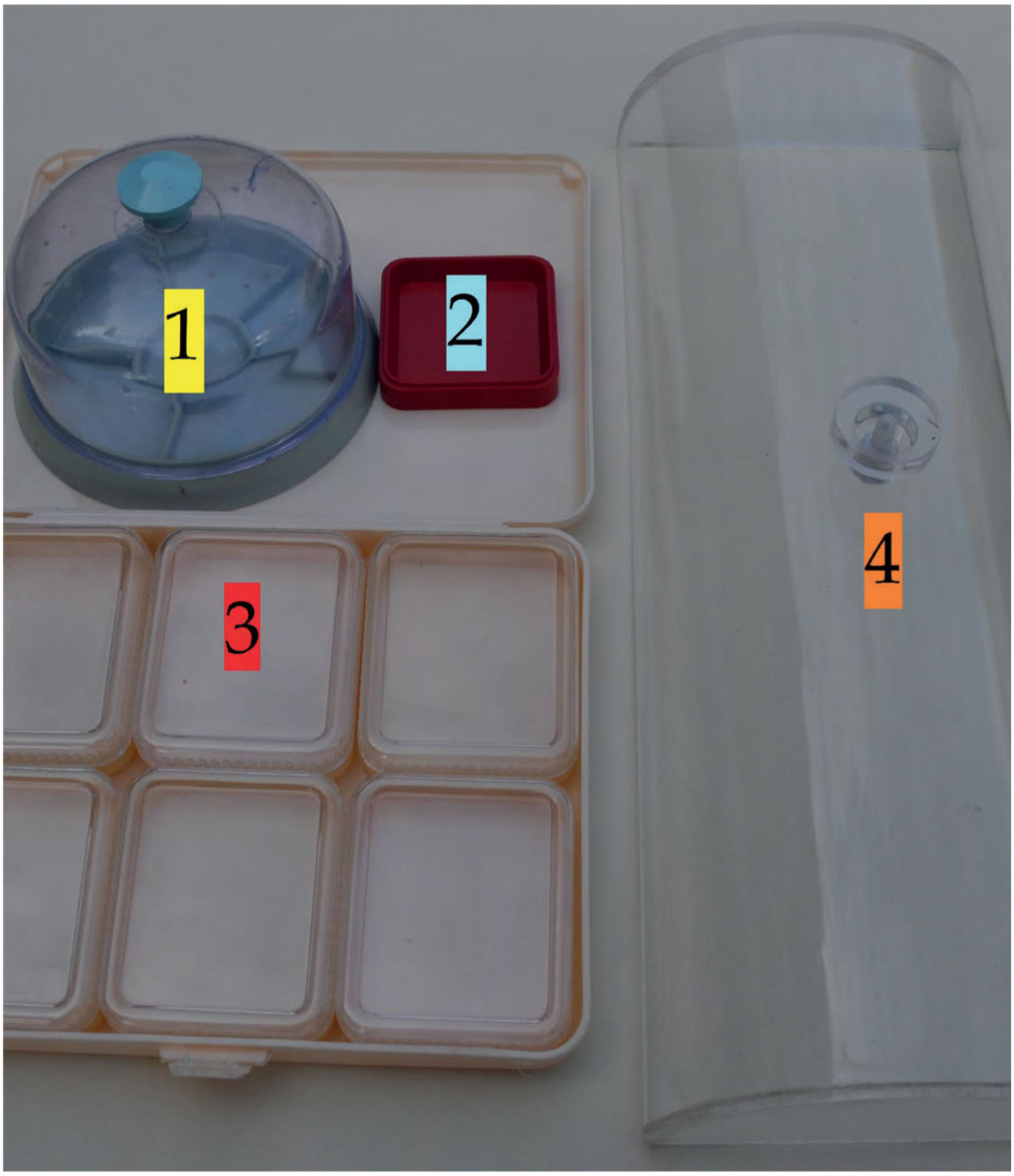


Fig. 8: Typical set of Swiss pin vices.

There are two main types of pin vice: individual ones, and a universal type. The individual ones come in four sizes, each having two jaws (collets) as in image 1, Fig. 7, a fine one and a large one, one fitted in the head, and the spare in the tail end of the holder. These are normally made by Bergeon in brass and steel, with the flashier type being chrome plated, or the cheaper Eclipse with a gun-black finish.

Alternatively there is a universal type which is a four-in-one type of tool. There are four different types of collet, which can hold round objects from 0–3mm in diameter. This is a cheaper tool, but I personally find it a bit annoying as you have to keep changing the collet for different jobs.



Parts Tray

Fig. 9: Storage boxes and dustcovers.

The parts tray should be large enough for a 4cm movement, and it can be anything you think is up to the job, from a tool shop or a fishing tackle shop. Some of my students like a box with many compartments, so they can separate and group each component as they strip the watch. A tray with a dustcover is a good choice if you work full time, as this will keep the components dust free and safe from handling by passers-by, and ready to be worked on later.

In the photograph, the first image shows the most common types of dustcover found in small workshops. In the second is a type of tray that stacks one on top of the other. The third shows a good box for storing clean watch movements as it is a box in a box, which helps to keep the dust out. In the fourth is a bench dustcover, ideal if you stop work to have a teabreak, as you can cover any watch or your tools with it to keep them dust free.

Movement Holder

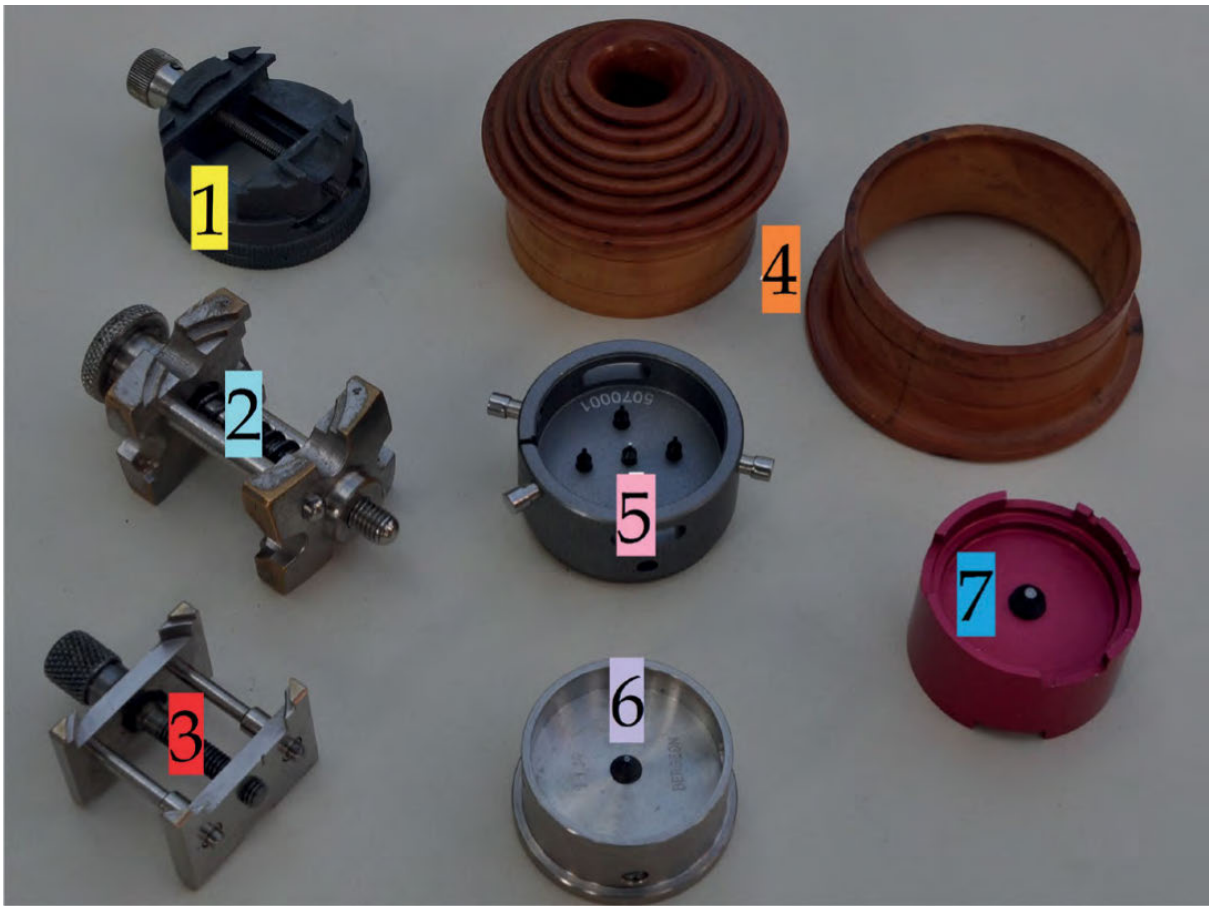
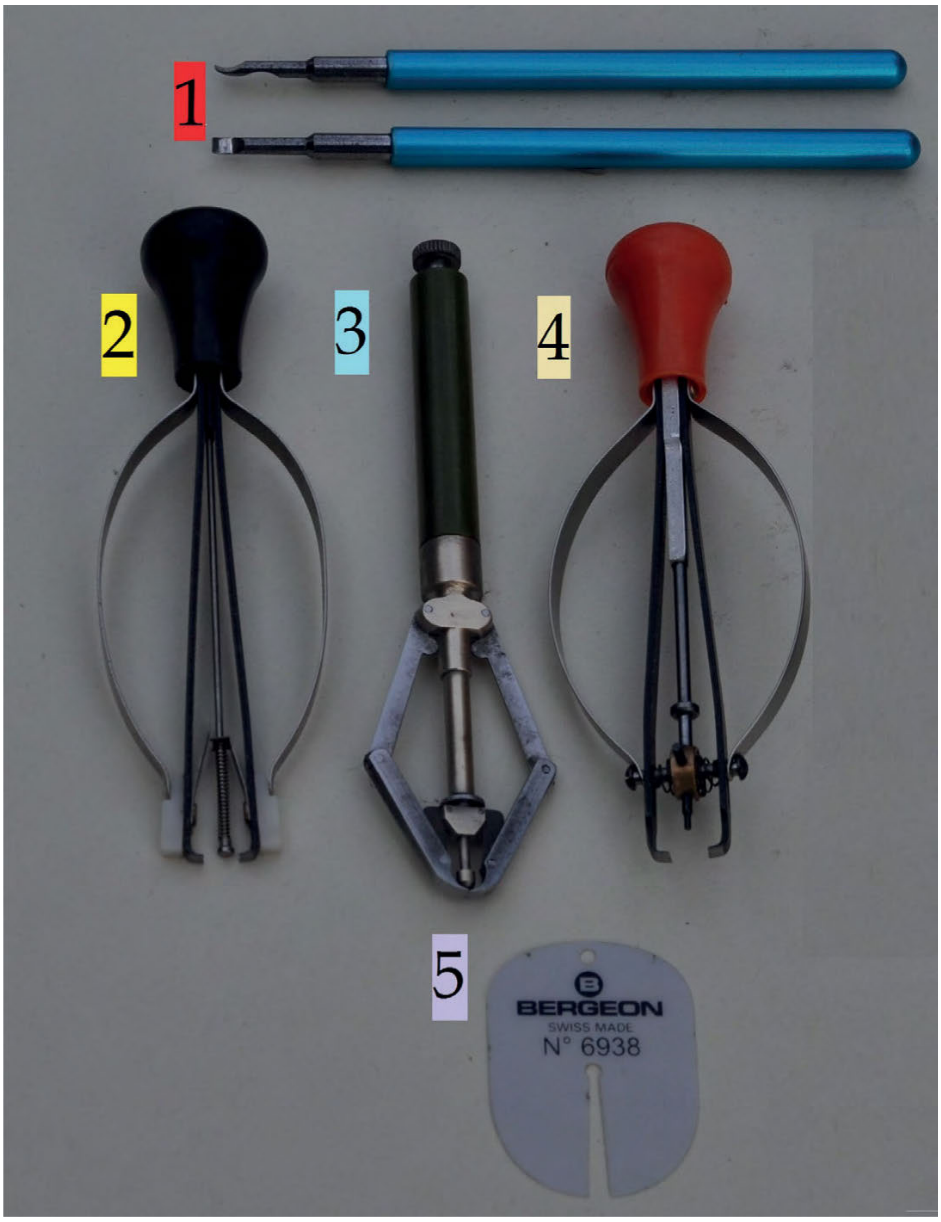


Fig. 10: Various types of movement holder.

The most common type of movement holder is like a small vice with various sizes of jaw (as seen in images 1, 2 and 3 of Fig. 10). The jaws are adjusted by the central screw, to fit many sizes of movement. This type of holder keeps the watch secure in its jaws; however, it has the disadvantage that it will very slightly mark the movement, thus the newer types are made from carbon.

In image 4 it can be seen that movement rings are as they sound: rings of plastic on which a watch movement can be rested as work is performed. I prefer using rings for larger movements, such as in pocket watches, and I use the vice type for wrist watches, as I find wrist watches are less secure on a ring and more likely to be damaged if the movement slips off. The older type of movement rings were made from boxwood, unlike their modern counterparts, which are made from plastic.

Images 5, 6 and 7 are the professional's choice of movement holder, used by service centres and designed to fit a particular movement: they will not mark the movement in any way, and will also support delicate parts in the watch.



Hand Removers

Fig. 11: Tools used to remove watch hands.

Hand removers come in primarily three types, and levers are similar to car tyre levers, but not in size. They are the same approximate length as a teaspoon – as in image 1 in the picture.

There is also the spring-loaded lifting type – as seen in image 2 – called the ‘presto’ tool. I would recommend this type for a beginner, particularly for those who are a little heavy handed or nervous, as a lot of damage can be done with the free-handed levers. I find there is very little difference between the cheaper and the more expensive of these on the market, and they all seem to have the same lifespan.

Image 4 is a more specialist tool, used to remove the centre seconds hand on chronographs. The third type is quite old-fashioned and rarely seen in tool shops; similar to the presto tool (image 2), instead of lifting off the hands, this tool levers them off just like a pair of hand levers, because you push the handle of the tool down towards the dial of the watch.

Dial Protector

As seen in image 5, this is a thin piece of plastic that sits on top of the dial when the hands of the watch are being removed. It is normally white plastic with a V section cut out of its centre. Alternatively you can make one yourself out of a piece of paper.

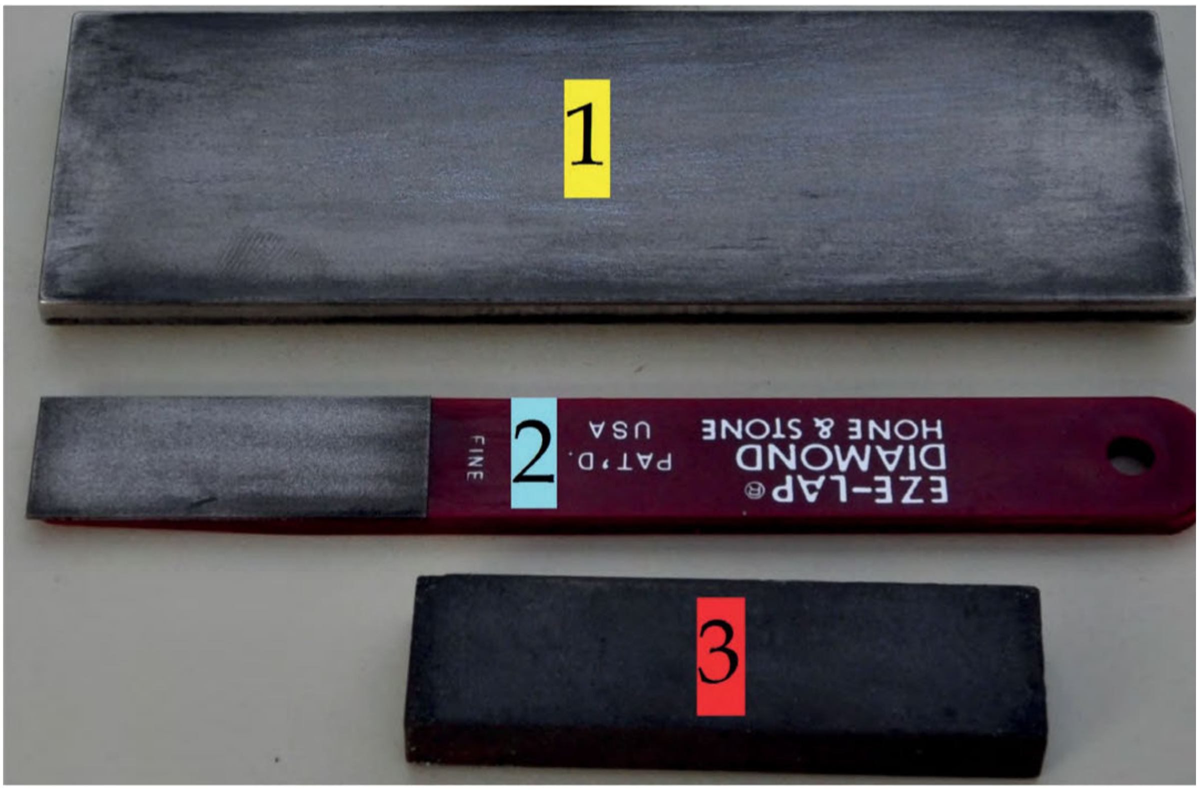
Apron, Knee Length

Even if you think you are not the apron type, I would strongly advocate the use of one, unless you wish to spend most of your time under the bench with a torch and magnetic strip – the apron will be a safety net to catch stray parts that try to make a run for it. It should preferably be white in colour, and with no pockets as parts will hide in them. Your life will certainly be made a lot easier by using one, as you will spend less time grovelling under the bench looking for the ever elusive part. A friend of mine fondly recalls his tutor in Switzerland calling this ‘under-the-bench watchmaking’.

The traditional attire for watchmakers has always been a white or blue laboratory coat. In the 1920s a watchmaker would also be required to wear a waistcoat and bow tie, but this is purely optional.

Two Large Bulldog Clips

Bulldog clips are used to secure the bottom part of your apron to the edge of the bench or table you will be working at, to create the safety net mentioned earlier. This is a personal choice; I never really liked this idea as it made leaving the bench a bit of a performance, especially if you forget that you are tied to the bench and the phone or the front door rings, and you strangle yourself as you try to leave the bench. Nevertheless, some of my students have had great success with this method, so I deemed it worthy of a mention. Alternatively you could use Velcro, one part glued to the underside of the bench and the other sewn to the apron.

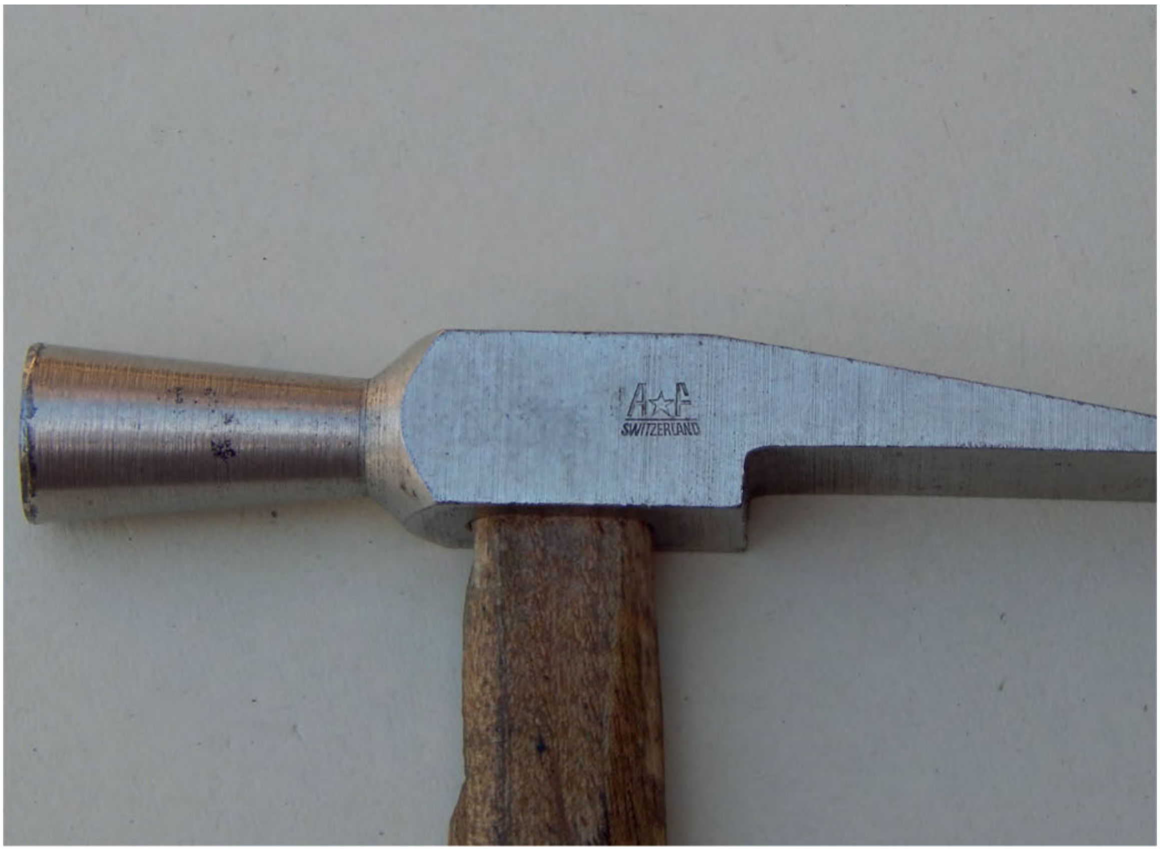


Sharpening Stones

Fig. 12: Sharpening diamond and oilstones.

A sharpening stone can be an India stone, as seen in image 3: this is a hard, dark brown stone that normally comes with two grades of sharpness – medium on one side and coarse on the other. Alternatively you can use a diamond sharpening stone with a medium grit, as seen in image 1. These can be easily obtained from hardware shops and material suppliers, normally being advertised for sharpening knives. They seem to vary quite a lot in price, but I struggled to find any difference in quality – though keep away from diamond stones that seem to have perforated holes in the surface as these are unsuitable for watch repair.

A good India or diamond stone will be needed for keeping the tips of your tweezers in good condition, and for sharpening/adjusting screwdrivers. The diamond stone has the advantage in that it will cut more quickly than the India stone, but if you are on a budget the India stone is cheaper. If you buy a secondhand India stone, make sure that the cutting surface is flat, as they invariably tend to have hollows worn in them, due to incorrect use. They must be used with oil, and you should always work your way around the stone when sharpening, to prevent wearing the aforementioned hollow in the stone. Image 2 is a diamond lap: these are great for sharpening screwdrivers, and are used when replacing watch winding buttons.



Watchmaker’s Hammer

Fig. 13: Watchmaker’s hammer.

The watchmaker’s hammer is like a cross-peen/pein hammer in shape. I would advise the light- to medium-weight hammers with a head weighing 30–40g, measuring 50–60mm in length. Any bigger will only be good for heavy engineering: as is typical in the watchmaking world, smaller is better. A crosspeen hammer has a round cylinder business end, with the opposite end being a protrusion shaped like a pelican beak. N (Note that a watchmaker's hammer is not needed to begin with.)

Watchmaker's Wand

Yes, I did say 'wand' – and the 'spell' is 'accio' and then say the watch part's name. If only! In the real world, the wand is a homemade piece of 'magic' consisting of a 30cm ruler, or ideally a piece of scrap wood about 40cm long, 5cm wide and 2/3mm thick. On this surface affix two rows of self-adhesive magnetic tape, which can easily be found on internet websites, and there you go – a wand. Most watch parts are made of steel or have some steel attached to them, and if you do drop something it will be picked up by your wand.

If you don't regularly clean the workshop floor or work space you will soon find every piece of metal that has found its way on to the floor since you last cleaned – so make sure you clean the floor every other day you work so it is easier to find any lost pieces.

Remember that watches and magnetism are not friends, and any parts that are picked up with a magnet will need demagnetizing with the use of a demagnetizer. If you are not into making homemade tools, Bergeon make a tool called the 'magic wipe' (Bergeon number 7871).

Demagnetizer

You will certainly need a demagnetizer if you are planning on using the watchmaker's wand. There are two types of demagnetizer on the market: the coil type and the electronic type. The coil type is the cheapest, and I would recommend these to start with. They are available in two forms. One is oval shaped, about 10cm (4in) wide and 2.5cm (1in) high, with a hole in the centre, in which you hold the object to be demagnetized. To activate the device, press and hold the button and slowly move the part away from the device to about 30cm. Let go of the button and the magnetism should have been removed, or certainly reduced.

The other coil type is normally a rectangular plastic box, typically blue or white with a red button. To activate this device, again place the object in the middle of the box, press and hold the button and pull the part away from the tool slowly and then let go of the button. (Check out Cousins. uk, code D38206 for this device; it's cheap at £ 14.95 – information at the time of writing.)

The electronic demagnetizer is the tool of choice for the professional, and is very expensive. However, if you are handy with a soldering iron and good at reading wiring diagrams, then you can look on the internet where you will find a web page showing you how to make one, set up by a clever person in the States. To use this tool is very simple: hold the part over the space marked on the equipment, and tap the button – and the job is done. Some devices require you to rotate the item 180 degrees and repeat the process to eliminate the magnetism on both poles.

It is important to remember that although it is simple to demagnetize whole movements, if you are planning on demagnetizing small parts, it is advisable to put these in a small, sealable plastic bag.

Compass

A compass is used for detecting magnetism in a watch or on tools that are made of steel. If you wish to know if something has become magnetized, then pass the item in question over a compass. If you observe its needle moving, then the part (or watch) has a magnetic field. The type of compass I would recommend is the sort normally found in a Christmas cracker. Any type is suitable, as long as it is light. The Swiss make a compass specifically for this job: it looks just like the cracker type, but comes in a little wooden box with a hinged lid, and, as you may already have guessed, is very expensive.

Rodico

Rodico has the consistency of Blu-tack. This putty-type material is used for removing fingerprints from a watch; it can also be used for removing small particles of dirt and for picking up small parts. Bergeon and A & F both make a version of this product. Do *not* be tempted to use actual Blu-tack, which is not the same, even though it may have the same consistency, because it contains oils that Rodico does not.

Best practice with Rodico is to put a small blob on the end of a piece of peg wood, rather than holding it between your fingers. Store Rodico in a small plastic bag.

Peg Wood

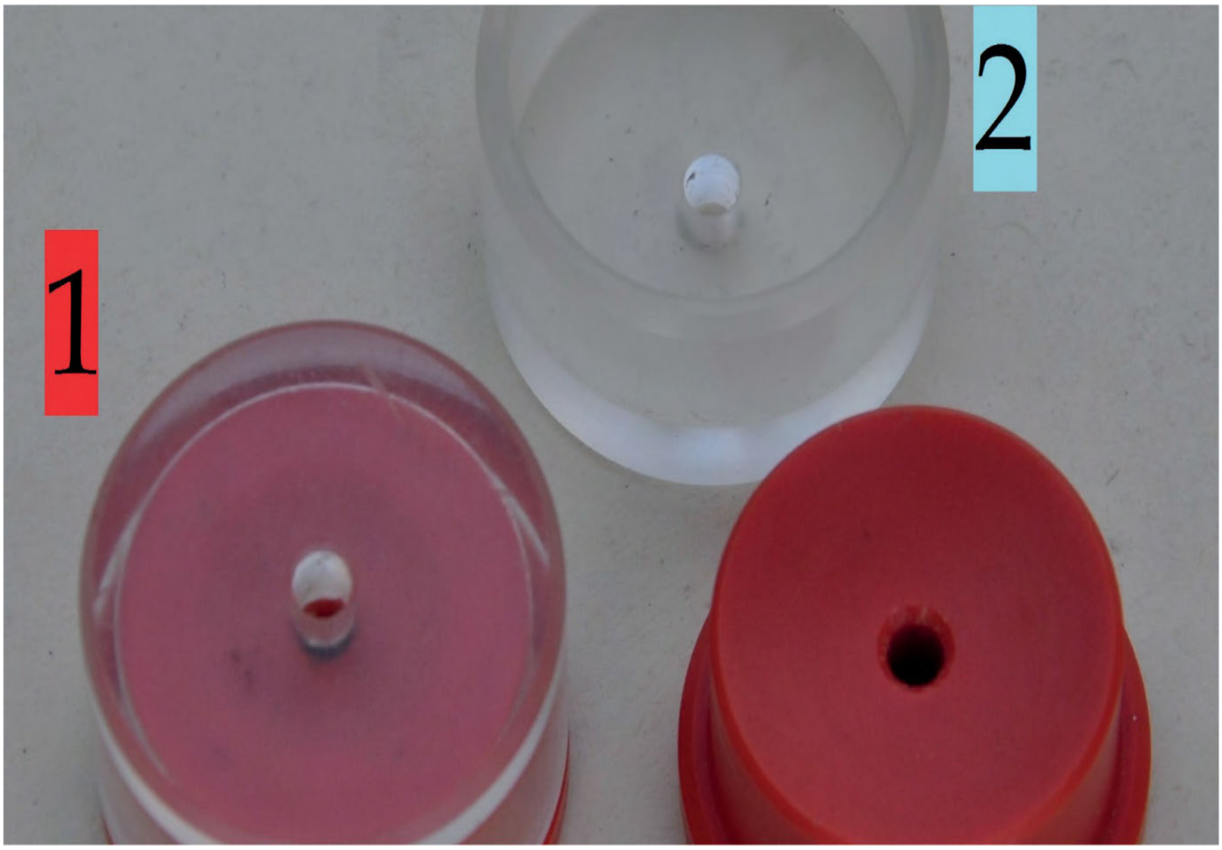
Peg wood comes in many different sizes; for now I would just recommend getting a small bunch of sticks. The one I use has a diameter of 2.5mm (other diameters are available) and looks a bit like the wood used as cocktail or cheese sticks. This again is used in the cleaning of watch jewels. Do not use cocktail sticks, as the wood’s sap/resin may not have totally dried off.

Peg wood can be used to mop up small amounts of excess oil, but you must remember to trim off the contaminated section each time.

Finger Cots

Like rubber gloves in the car trade, finger cots have taken a long time to catch on, as they resemble prophylactics and turn grown men into giggling boys. They are typically used when handling a clean watch movement or during reassembly after cleaning. This is to prevent sweat and acid from your fingers contaminating and damaging the plating on the watch, and to prevent any steel components from rusting. Normally, finger cots are worn on the left hand, covering three or four fingers; this leaves the right hand uncovered, normally the hand that will hold the tweezers. Finger cots can be purchased from pharmaceutical suppliers.

Traditionally acid-free tissue was, and is still used by some diehard watchmakers. The tissue acted as a barrier between the fingers and the watch movement.



Barrel Closer

Fig. 14: Image 1: Barrel closing tool; Image 2: Showing the two parts of the tool.

Again, a barrel closer is not essential, but will prevent damage to the barrel. It can be made with two bits of round plastic about 2cm in diameter with a 2mm hole at their centres.

Resealable Plastic Bag

A bag approximately 15cm in size is normally used when removing click/return bar springs.

2. CARING FOR YOUR TOOLS AND USING THEM

THE WATCHMAKER’S SCREWDRIVER

The first thing you should do before working on any watch is to make sure that your screwdriver blades are in good condition and will fit the screw slots in the watch you will be working on. It is vital that you do this, otherwise you will most definitely damage the screw heads in the watch, and there is nothing worse than a watch with damaged screw heads. Watch screws normally have a mirror finish to them, and if they become chewed up, not only do they look horrible but it is certainly more difficult to remove a damaged screw later on. It is also considered very bad practice in the watch repairing trade, and will give you a bad reputation.

Before you start work, you should pick out only the screwdrivers that you will be using for the job, as it is unlikely you will use all of the ones in your set. Remember that the screwdriver you pick for each screw must be as nearly as wide as the screw that you will be using it on.

If your screwdrivers are new and Swiss made, then you will only have to do a little preparation to get them fit for the job. If they are of cheaper origin then you will most certainly need to sharpen them.

Using Screwdrivers

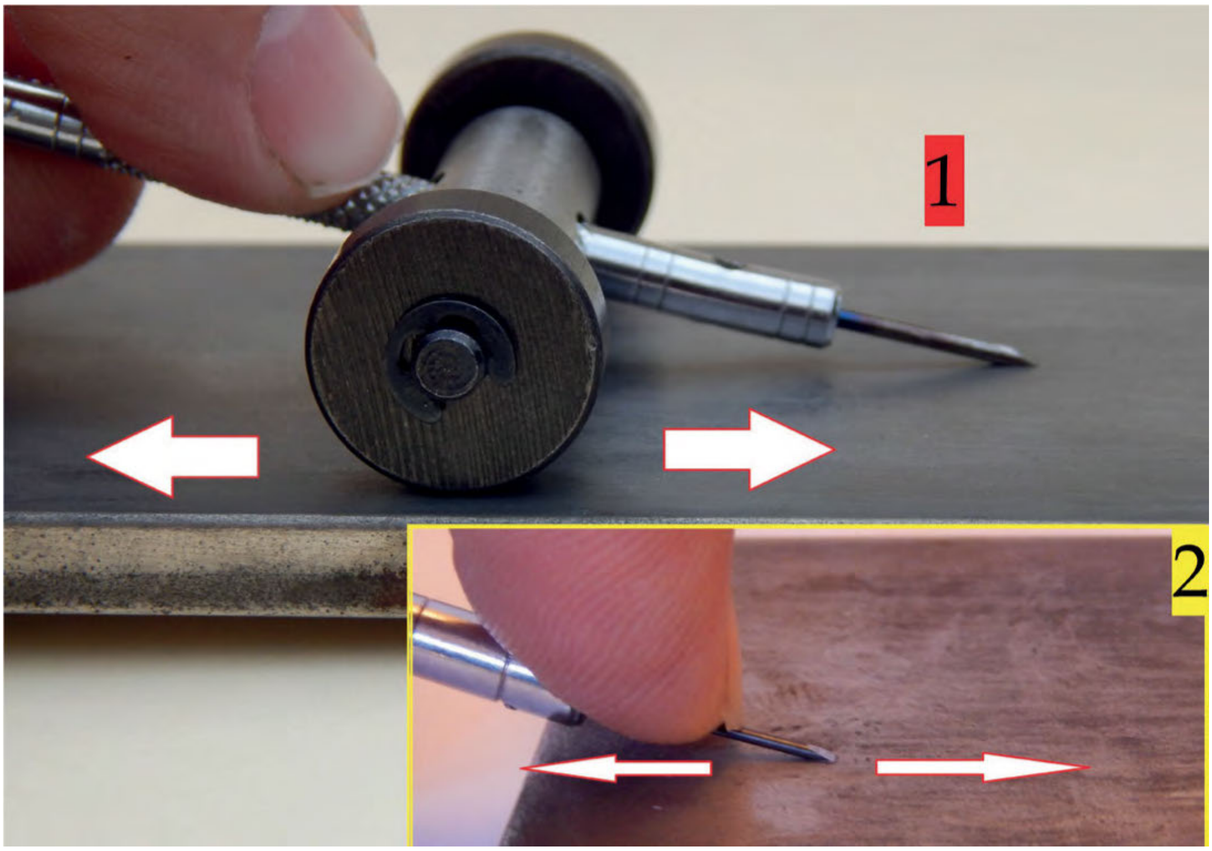


Fig. 15: Image 1: sharpening a screwdriver with a sharpening tool, rolling it back and forth along a diamond sharpening stone; flip the tool over to sharpen the opposite side. Image 2: sharpening a screwdriver by hand.

First, pick a screw and then the appropriate screwdriver, and place the blade in the slot of your screw of choice. Give the driver a slight wiggle in the slot to test the fit. The chances are that the blade will be too thin for the slot. We are looking for a blade that is a snug fit in the slot, and we also need to make sure that the blade touches the bottom of the slot.

If the driver blade is too thin

If your screwdriver blade is too pointed this will leave the blade very weak at the tip. If you try to undo a screw with this type of blade, not only will you damage the screw, but the end of the blade will shear off, possibly causing the screwdriver to slip and probably scratching the surrounding plate. I cannot stress enough the importance of getting your screwdriver blades to the correct shape, with the correct width of tip.

Using your sharpening stone, flat on a bench, place your screwdriver's blade tip upright on the stone and drag it along the surface of the stone to shorten the tip. Make sure you keep the screwdriver upright and square to the stone to preserve the right angle profile of the blade's shape. Moving the tip about 3cm along the surface of the stone will probably be all you will need, especially if you are using a diamond stone.

Tip: If you're using an oilstone, remember to use oil.

If the blade is too fat

Correcting a blade that is too fat is a slightly trickier job, and will take a bit of practice to get right. You will be using the stone again, but this time it is the side profile of the blade that is going to be sharpened. This means that the screwdriver will have to be held almost parallel to the stone at the desired angle, preferably the same as the original V shape of the blade. Stroke the blade back and forth on the stone about ten times, then inspect your handiwork. Then turn the screwdriver over and sharpen the opposite side in the same manner.

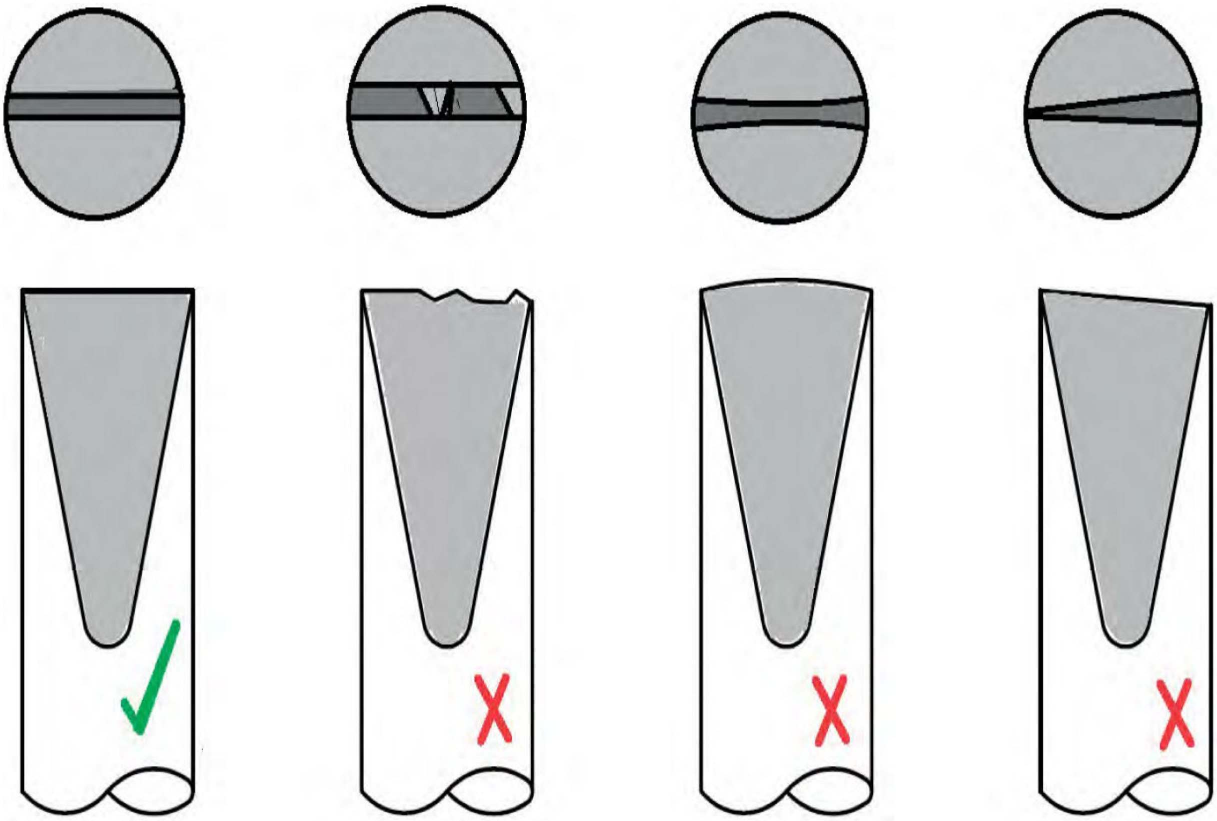


Diagram 1: Correct shape and proportions of a screwdriver blade.

The side angle profile must be tapered, almost resembling a pair of hands in the praying position. Both sides must be equal, and the length of the taper must be twice as long as the width of the blade. As a rough rule of thumb, the width of the tip should be one tenth of the width of the blade.

Make sure that when you look at the end tip of the screwdriver, the profile does not resemble a wedge of cheese or a carrot in shape. The profile must be rectangular. All sides should be parallel. The profile must not be fat in the middle or thin on the edge. Remember to take your time during this process, as rushing will ultimately lead to damaged screws.

Note: The industry now prefers you to use hollow ground screwdriver blades. This is impossible to achieve by hand satisfactorily, only with the aid of a very expensive tool. For beginners, I would suggest using the measures described above.

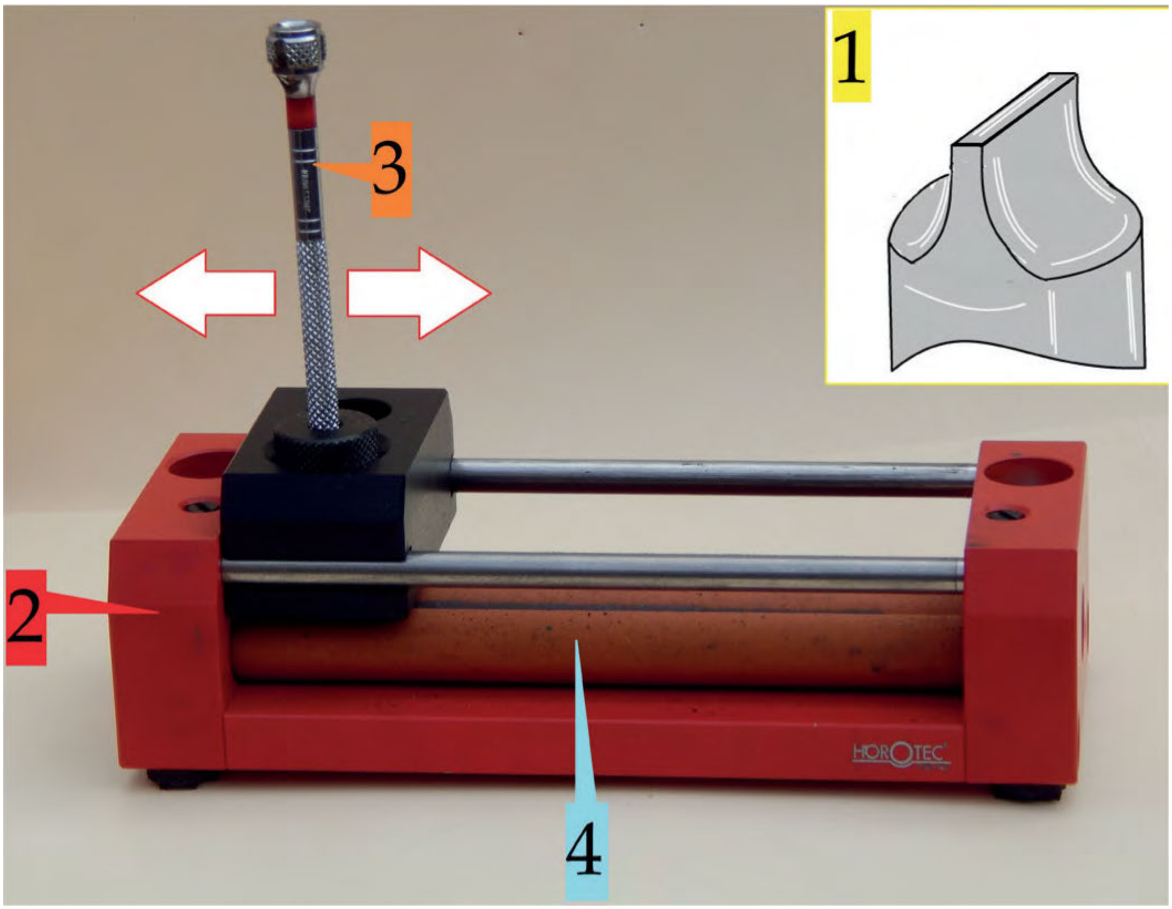
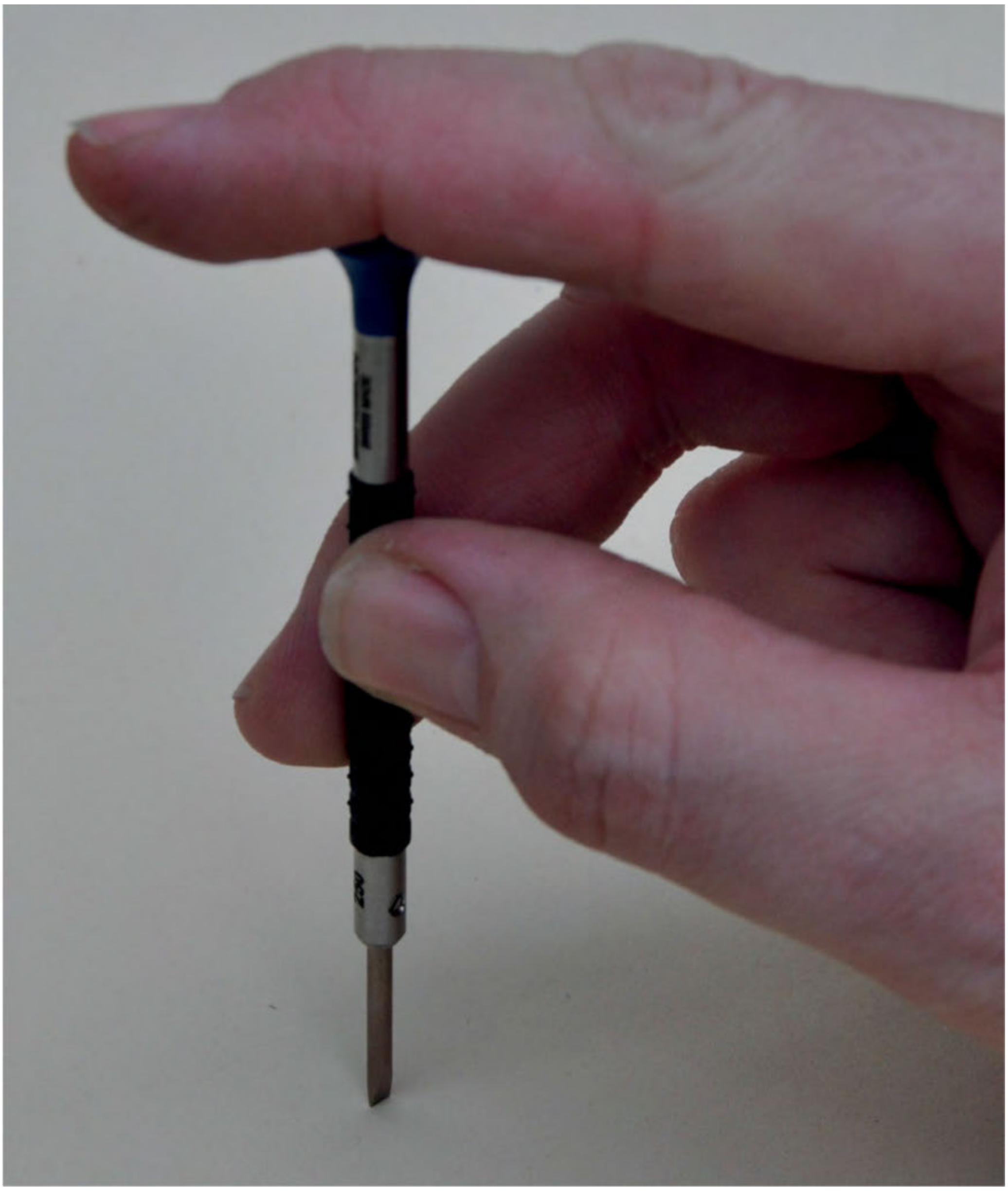


Fig. 16: The Horotec tool (image 2) used to create a hollow ground screwdriver (image 1). Insert the screwdriver (image 3) into the carrier, then move it back and forth over the two round sharpening stones (image 4). A hollow ground screwdriver is no good for the jobbing watchmaker who works on a variety of movements, as the tip is not easily modified. It is best left to those working in factories and service centres.



Holding the watchmaker’s screwdriver correctly

Fig. 17: The most usual method of holding a watchmaker's screwdriver.

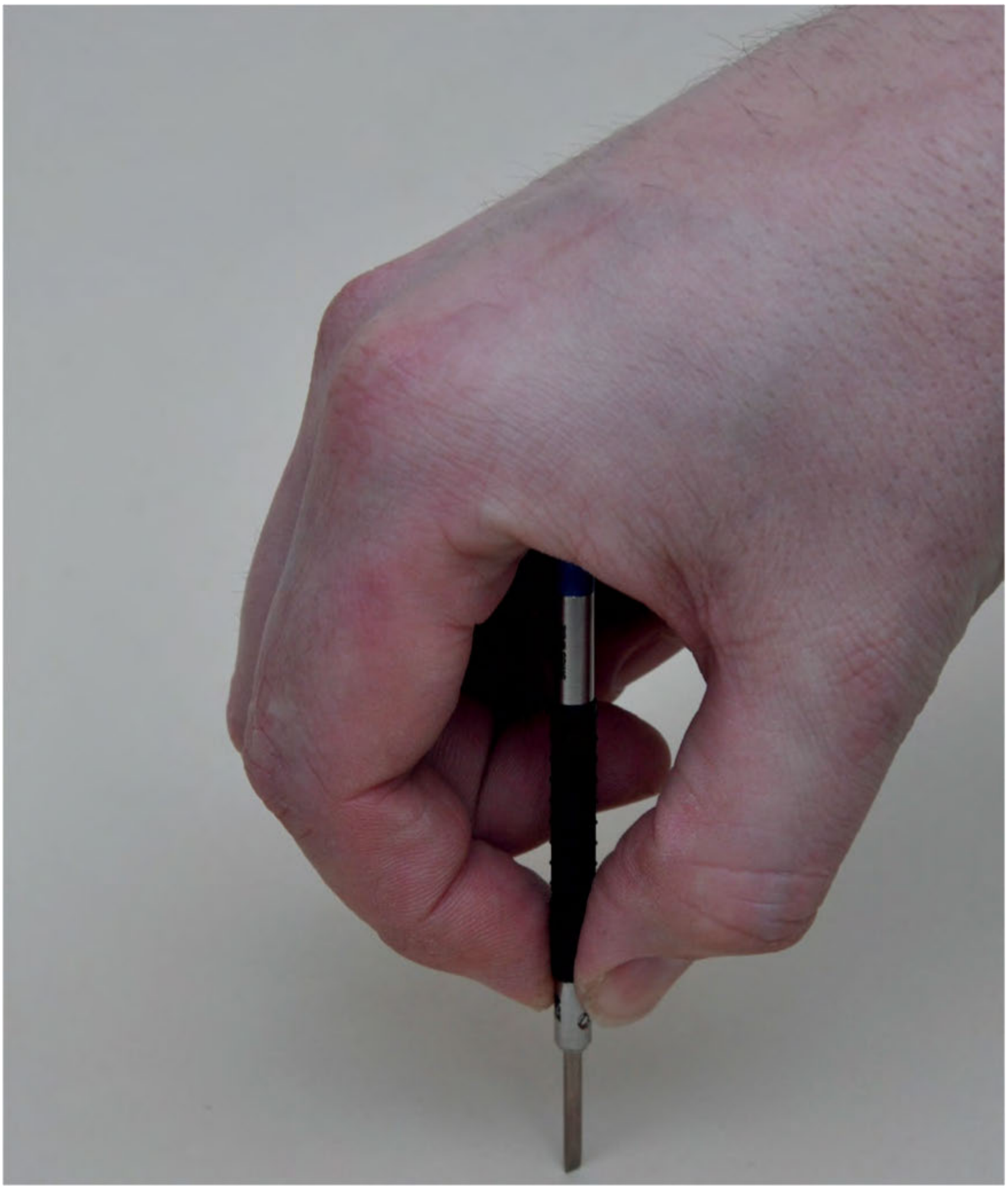


Fig. 18: Alternative method of holding a screwdriver, best used on very tight screws.

If a screwdriver is used incorrectly a lot of damage will be caused to the watch you are working on. This may be hard to believe, but who knows, maybe one day this very watch will be the last of its kind and may be sitting in a museum for all to see, and a keen observer may comment 'How sad that someone in the past damaged this rare watch'. Stranger things have happened: swatch watches have become collectable.

Basically you hold (almost pinch) the middle part of the screwdriver (the part with the serrations or knurled part) with your thumb and middle finger, and rest your index finger on the top of the screwdriver. The top of the screwdriver is known as the swivel. Pop the screwdriver's blade into the slot of the screw you wish to undo, and then rotate the screwdriver with the thumb and middle finger; the downward pressure of the index finger on the swivel will keep the screwdriver's blade in the slot during the unscrewing process.

The most common mistake to make is to place the tip of the index finger on the swivel. The correct position is to rest the middle part of the index finger on the swivel instead (see Fig. 17). This is essentially locking the finger, making the screwdriver more stable during use.

You should also rest your wrist on the bench, or use your little finger as a steady on the bench to keep your entire hand steady. This will not feel comfortable to start with, but you will soon get used to it. This is a similar method that surgeons use to keep their hands steady during operations. Alternatively you can rest your hand on your cheek or forehead for support instead. This steadying is exceptionally important, as an unsteady screwdriver will most certainly slip and you will undoubtedly scratch the watch.

With a screw that is very tight, there is a second method of holding the screwdriver to prevent its blade from jumping out of the slot. To do this, rest the swivel in the crux of your finger and thumb, and then use your index finger and thumb to undo the screw (see Fig. 18).With this method more pressure can bear down on the screw head to help prevent unwanted movement of the screwdriver's blade.

THE WATCHMAKER'S TWEEZERS

Using Tweezers

This is not so much about holding the tweezers, but how you pick items up with them, because tweezers can make very good catapults and you can easily fire the part you have just picked up across the room. The trick is to make sure that, whatever you pick up, your tweezers are holding on to as much of its surface area as possible. You should also apply the right amount of pressure to the tweezers at all times. To practise this, you should be able to pick up a screw and then rotate the tweezers between your index finger and thumb without letting go of the screw.

Tip: To replace screws in a watch, pick up an individual screw by the thread, as close to its head as possible. This is so you can offer up the screw to the watch and balance the bottom of the screw in the screw hole, ready for screwing in with the screwdriver. If you struggle to balance the screw in the hole, you can support it in the hole with the tweezers in your left hand, and tighten it up with your right hand.

Tweezer Maintenance

Of all the tweezers I have bought over the years, every single one has been far too springy and stiff for my liking. I find this to be a real disadvantage, because when you try to pick up something with them, you have to squeeze so hard there is a high chance that you will shoot the item out of the tips.

The first remedy is to grab the tweezers where the two bits are welded together, and give them a slight bend in either direction. This will remove some of the springiness, making them softer to use.

The second remedy is to place about 3cm of the tip end of your tweezers in a bench vice, making sure to hold them only lightly, as you don’t want to damage the tips. Do not use a vice that has plastic jaws, because as you will see, they will melt. With a gas torch (such as those used for making crème brûlée, or a gas torch you can find in a DIY store) or a heat gun used for paint stripping, heat between the rounded end of the tweezers and the area where the two parts of the tweezers meet. Hold the heat in this position until the metal just starts to turn red (cherry red). Now slowly pull the heat away from the tweezers so that they don’t cool too quickly, otherwise you will not achieve anything.

When you have finished, you will need to clean up the tweezers with some 800-grit emery paper as they will be blackened. But if all has gone as planned, you should have tweezers that are less springy. (Personally I feel they are similar to an F1 car: you need to fine tune them so that you can feel what is happening at the business end.)

With constant use your tweezers will probably start firing out the parts as quickly as you pick them up. Often this is because they have been dropped on the floor, or perhaps you’ve been a little rough with them. If this is not the case, then it is most likely that the tips have just become polished. This is very easily remedied by using a diamond stone or a piece of emery paper lightly on the inside surface of the tips, to roughen them up slightly with one or two rubs.

If you have dropped your tweezers or been overly rough with them, you will most definitely have bent their tips. Even if at first glance they don’t seem bent, I can assure you they will be. Give them a hard squeeze, at the same time looking through your eye glass at their tips in front of a bright light: if they are bent you will see a small sliver of light at the very tip. To straighten them, use a pair of pliers with smooth jaws and simply bend the tips very slightly. If you see them bend, you have overdone it – just remember it is a very light adjustment! Recheck under a light to see if you have improved them. Once you are happy they are back to normal, take a diamond stone or India stone to flatten both inside tips, and to make sure all is parallel.

If you have been really unlucky and one of the tips has broken off, you will have to shorten the other tip to the same length, in the same fashion as if you were making your screwdriver tip fat. You will then have to thin down the sides of the tweezers to try and make the tips fine again. This can be accomplished by using the diamond stone, or a diamond file if you wish to speed things up a bit.

If your tweezers are No. 3s, then they would have been rounded at the end, and to replicate this, you will have to use the diamond stone. Place the area to be shaped on the stone as you would if you were stoning the sides, but this time as you sweep back and forth, you have to rock the tweezers at the same time. With a bit of time and care you will soon restore them to good as new.

You might be thinking 'I'll just buy new ones'. That's fine in theory, but remember that you are used to the tension of those tweezers, and a different pair will feel strange to you, just like driving a hire car. Flicking watch parts around your room all day will certainly leave you feeling frustrated, and will probably make you feel you just want to give up entirely. The hardest thing to do in the world of watch repairing is to overcome your own frustrations and just realize that things like this do, and will happen. There is no point in getting upset about it: just walk away and come back later. Things are sure to get easier with practice – and even professionals have bad days, too.

HOUSEKEEPING

A modern watch repairer should keep their workspace like a small operating theatre. Just as doctors are constantly trying to keep out nasty bugs and diseases, watch repairers are trying to keep out stray fluff, hair, dust and dead skin cells, as any of these items can stop a watch dead in its tracks or cause an intermittent fault. Believe me, this is not a joke.

Clean your Bench

Before you start work on a watch, you must sweep the floor round your bench, as this will make life a lot easier if you are unlucky and drop something on the floor. After waiting for the dust to settle (literally), clean the work surface that you are going to be using with an anti-static surface cleaner and a lint-free cleaning cloth. You clearly don't want fluff deposited all over your nice clean surface area.

Clean your Tools

Not all your tools will need cleaning: it’s generally the ones that get used the most (such as your tweezers and the movement holder).To clean my tools I use ultrasonic jewellery cleaner with a water-diluted jewellery cleaning fluid. If you can’t obtain these, soak your tools in a washing-up bowl with a few drops of washing-up liquid, and scrub the nooks and crannies with an old toothbrush. Then rinse them in very hot water so their surface heats up, which helps the water evaporate, preventing any steel they might contain from rusting prematurely. Leave them for five minutes on a piece of kitchen towel to dry off completely.

I normally clean my tweezers and movement holder about every three days. The rest of my tools get cleaned once a week, and I use trade alcohol wipes as this is much quicker.

You may decide to set up a workshop in a shed. If this is the case, be sure to keep a watchful eye on your tools as they are more likely to rust in a shed than in your home, due to the increased chance of damp. This is especially true during the night and in the early morning. In the days when I had a workshop at home, I used to keep an electric greenhouse heater in the shed to keep my tools warm and to stop them from getting damp. If you are working in a spare room, I would also suggest that you avoid putting tools on the windowsill, as they too will suffer from damp.

If you are concerned about your tools rusting, a good tip is to apply a small smearing of oil on the surface – though remember to degrease them with the likes of lighter fuel or a watch degreaser before use, to avoid contaminating the watch you are working on with unwanted oil.

3. THE WORKSPACE

The ideal workspace is a clean, dust- and pet-free area with plenty of natural light, along with good bright lighting for the evenings. To begin with, I would recommend the kitchen (if you have an understanding wife or partner), as most have a tiled or laminate floor covering, and in theory should be clean. The floor covering is relevant because carpeted floor is a nightmare if you drop parts of a watch, as the small parts very easily get lost in the fibres of the carpet. If the only room you can work in is carpeted, one trick is to use a vacuum-cleaner pipe with a stocking covering the end: the stocking will stop the dropped item from being sucked up into the vacuum cleaner, and will hold it safe for retrieval.

Alternatively you can use a waiter's table brush, similar to the old push-along carpet sweepers but the size of a glasses' case. This can brush the carpet where you think the missing part might have disappeared, and hopefully it will sweep it up inside its collection box. As a normal rule of thumb, when you lose any part of a watch it should be in a two square metre radius of where you are sitting.

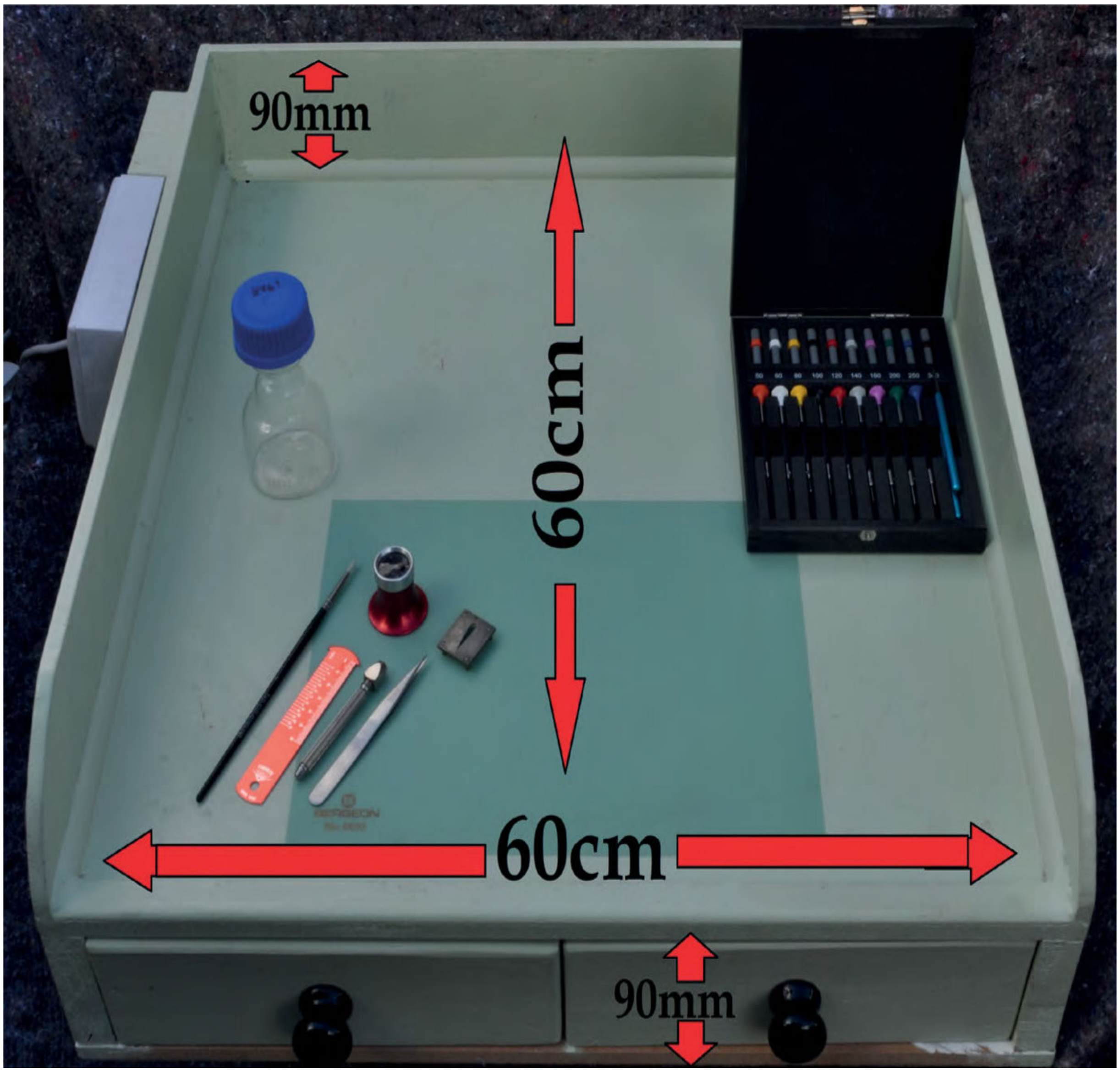


Fig. 19: Table-top watch repairer's bench, as used by Jeremy Barley.

BENCH

You should try and achieve a position at your bench so that you can almost rest your chin on it without bending your back or hunching your shoulders. This will put you at such a height that when you use an eye glass, you will be looking horizontally to the watch rather than from vertically above. This is very important, because you need to see a watch from all angles without having to tilt it, if at all possible.

You should also bear in mind that when you rest your outstretched arms on the bench your top half should form an approximate T shape, if you achieve the right height. This at first will not seem a natural position, so I would suggest a bit of experimentation to achieve a bench-to-chair height ratio that fits your body shape. This will greatly help reduce any back/shoulder strain that watch repairing can cause due to hunching your back and shoulders over a normal worktop. If you plan to use a microscope you will need a lower working surface or a heightened sitting position, the location of which will be down to trial and error.

Most modern professional workshops have armrests fitted into the bench top for more comfort, as sitting in this position for long periods can reduce the circulation in your arms, giving you occasional pins and needles. However, having armrests is only necessary if you plan to repair watches full time. The Swiss sell a custom-made bench with armrests, but these are phenomenally expensive to purchase. If you like the idea of armrests, you can just buy them on their own and fit them to your bench. The price for these is still quite high, but is certainly more affordable than the whole bench.

You could also buy or make a small watch bench (see Fig. 19) that can sit on top of most tables, making that work surface the right height to work on. I have seen many people working on them quite happily, but I personally have never used one so I cannot really pass judgement on them.

Whatever bench you have, the most important thing is to make sure that it is perfectly level. This will prevent tools and parts from rolling off it.

CHAIR

Most workshops use the normal office-type swivel chair with a height adjuster, so you can adjust the chair to the optimum height for you at the bench.

Tip: It may sound extravagant, but I would highly recommend a leather chair, because if you drop anything in your lap (which will be the one day you don’t wear an apron) you will find the lost item with relative ease, as opposed to losing it in a fabric-covered chair, where things can hide in the fibres.

One word of warning: if you have problems with your lower back, then I would recommend that you stay away from swivel chairs and use a standard old wooden dining-room type chair, and cut it down to the required height (though preferably not the family heirloom!).

BENCH LIGHT

Many people I know use an old-fashioned anglepoise light with a TCP T3 Daylight Helix energy-saving light bulb 240V 18W, which is really bright for an energy saver. These normally have the large Edison screw fitting, which you need to remember when you buy your light. The most common light seen in commercial workshops is a twin 30cm (12in) fluorescent tubed bench light or LED equivalent. I personally use the standard tubes, as I find that the daylight fluorescent tubes are as bright as a glow-worm, or maybe two glow-worms, to be fair.

STICK TO THE BASICS!

Before you get too excited making your shopping list for tools, and get carried away, taking watches to bits without reading the rest of the book, remember that we have all made the mistake of putting together that piece of flat-packed furniture without reading the instructions, and spending twice as long as we needed to complete the task. I strongly advise that you observe the basics, because if you start removing parts out of the watch you will soon learn the very hard and expensive lesson that they are little ticking time bombs literally ready to explode.

Rather than strip the movement in one go, I would recommend that at first you proceed in stages, following this book’s instructions, and understanding how each component reacts and interacts with its neighbour. Once you understand how a watch works, you should be able to put it back together with confidence. After all, it is just like a jigsaw puzzle: if you know what the picture looks like, then you can put the puzzle together much more easily. I would, however, recommend that you do not leave the watch in bits for long periods of time, as parts will inevitably go astray, no matter how careful you are. It is my recommendation that as soon as you have finished taking the watch apart, you should quickly put it back together again.

4. A BASIC MECHANICAL WATCH

A basic mechanical watch consists of seven main parts: the case, the power source, the gearbox, the winder and hand setting, speed control, the motion work, and the energy controller.

The case: Cases come in many different shapes and sizes. First, the case has to protect the machine inside, known as the movement; second, it has to be of a decorative design; and third, there has to be some sort of viewing window to see the indicated time shown by the dial and hands.

Power source: All machines need some type of power source to make them work, and with a mechanical watch, this comes in the form of potential/stored energy. This is the energy imparted on to the winder when rotating the button to wind it, just like a clockwork toy. This rotary motion passes through a series of small steel gears, which ultimately coil up a thin ribbon of spring steel into a tight coil inside the barrel. This steel ribbon spring is called the *mainspring*.

Gearbox: This is a large collection of gears (cogs) called the *geartrain*. In horology, these gears are called wheels and pinions. The larger brass gears with 50—120 teeth are called wheels, and the smaller steel gears with 6–20 teeth are called pinions. Their names are centre wheel and its pinion; third wheel and its pinion; fourth wheel and pinion; and the escape wheel and its pinion.

Winder and hand setting: Collectively known as the ‘keyless work’, this mechanism allows the winding of the watch and switches gears so the hands can be adjusted to the correct time; in some watches, there is the additional facility of a fast date setting.

Display: This is the face, also known as the dial, with the pointers known as hands. Underneath the dial is a series of gears that drive the hands around the dial. They are collectively known as the *motionwork*. The motionwork is driven directly by the centre wheel in the gear train.

Speed control: This involves the oscillator, known as the balance wheel. This swings back and forth at a constant rate thanks to a very thin, coiled spring attached to it called the balance spring. This is similar to a pendulum on a clock, and is kept in motion by the escapement (see *below* for an explanation of the escapement). Its speed is controlled by its mass and the length and thickness of its balance spring. This controls the speed at which the gears in the watch turn, allowing the accurate display of time on the dial.

Energy controller: This is known as the *escapement*. There are many kinds of escapement in the world of horology, the most common one found in modern watches being the lever escapement. The ticking noise you hear from your watch comes directly from the escapement, and it indicates that a small amount of energy has been held, released and spent to keep the balance wheel oscillating. The escapement holds the energy by stopping the escape wheel from rotating until the precise moment the energy is needed to give a push to the balance wheel. This push (known as the *impulse)* is given to the balance wheel to keep it in motion. The main part of the audible noise you hear is the locking or holding of the escapement.

Don’t worry if this all sounds a little complicated! Watches are not as simple as people think, and this will become much clearer as you go through the book.

5. TYPES OF WATCH CASE

POCKET-WATCH CASES

A plethora of watch cases has been made since the ‘dawn of time’ in the horological world. I will mainly concentrate on the more modern type of case made in the twentieth and twenty-first centuries and which you are more likely to come across, but I will also mention some of the older types, so you can understand the development of cases.

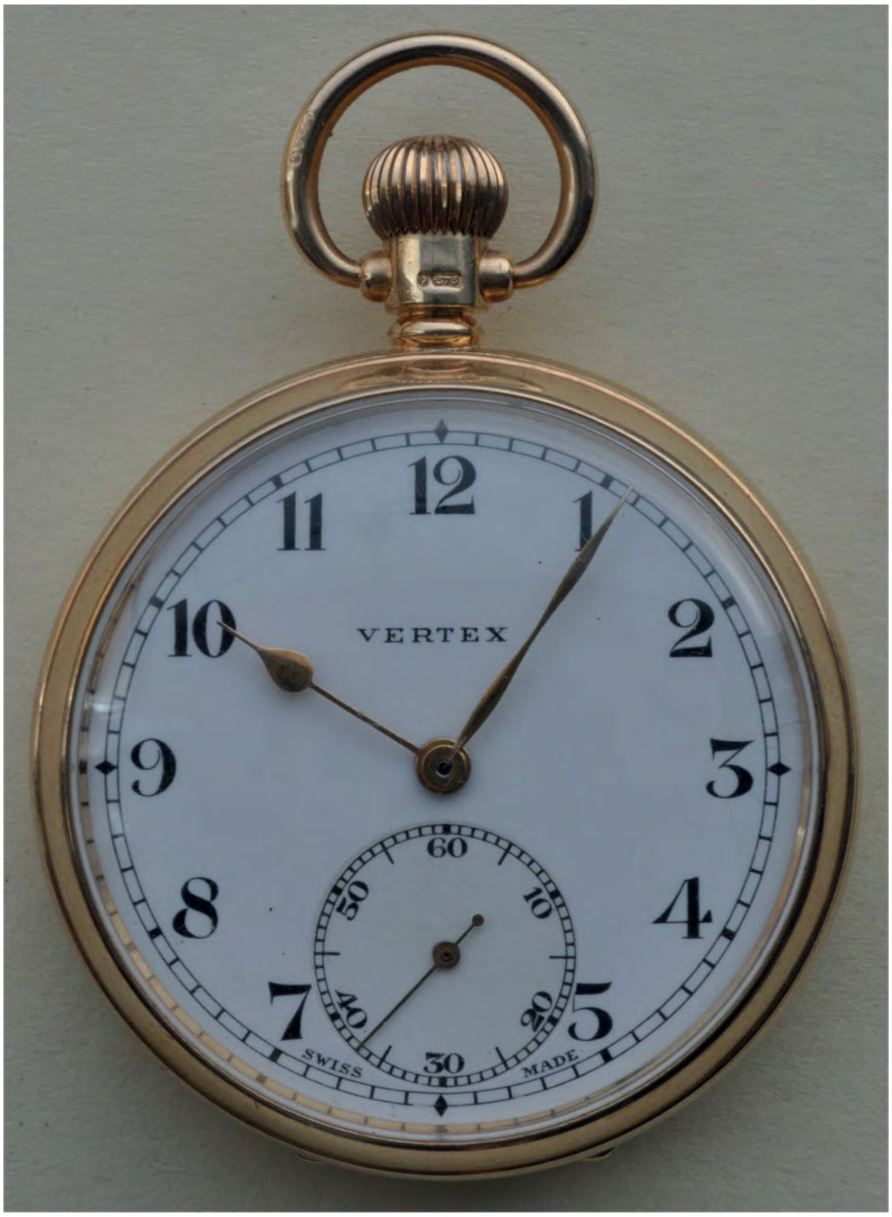


Fig. 20: 9ct open face pocket watch made by Vertex.

The most common type of pocket watch case, which no doubt you will have seen, is normally referred to as an open face pocket watch.

The Hunter Case

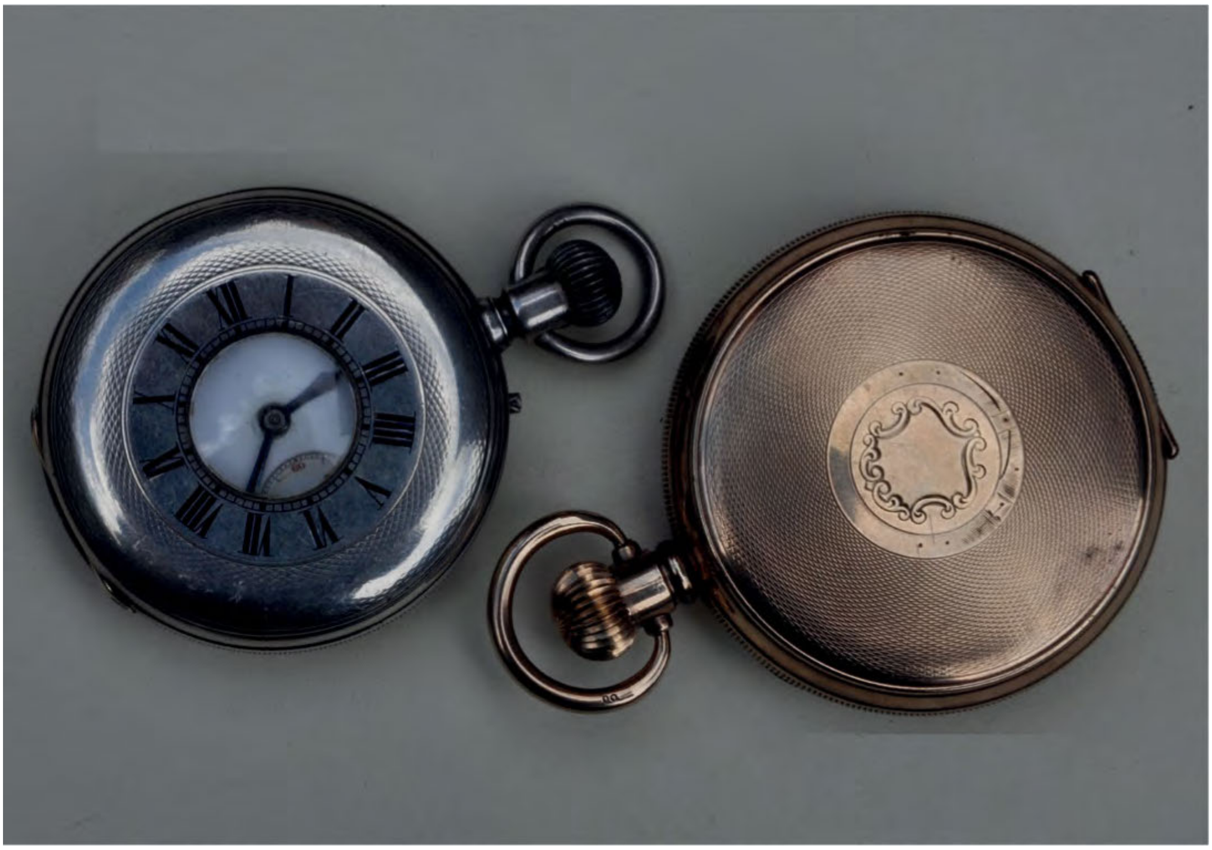


Fig. 21: Left: Half-hunter pocket watch. Right: Full hunter pocket watch.

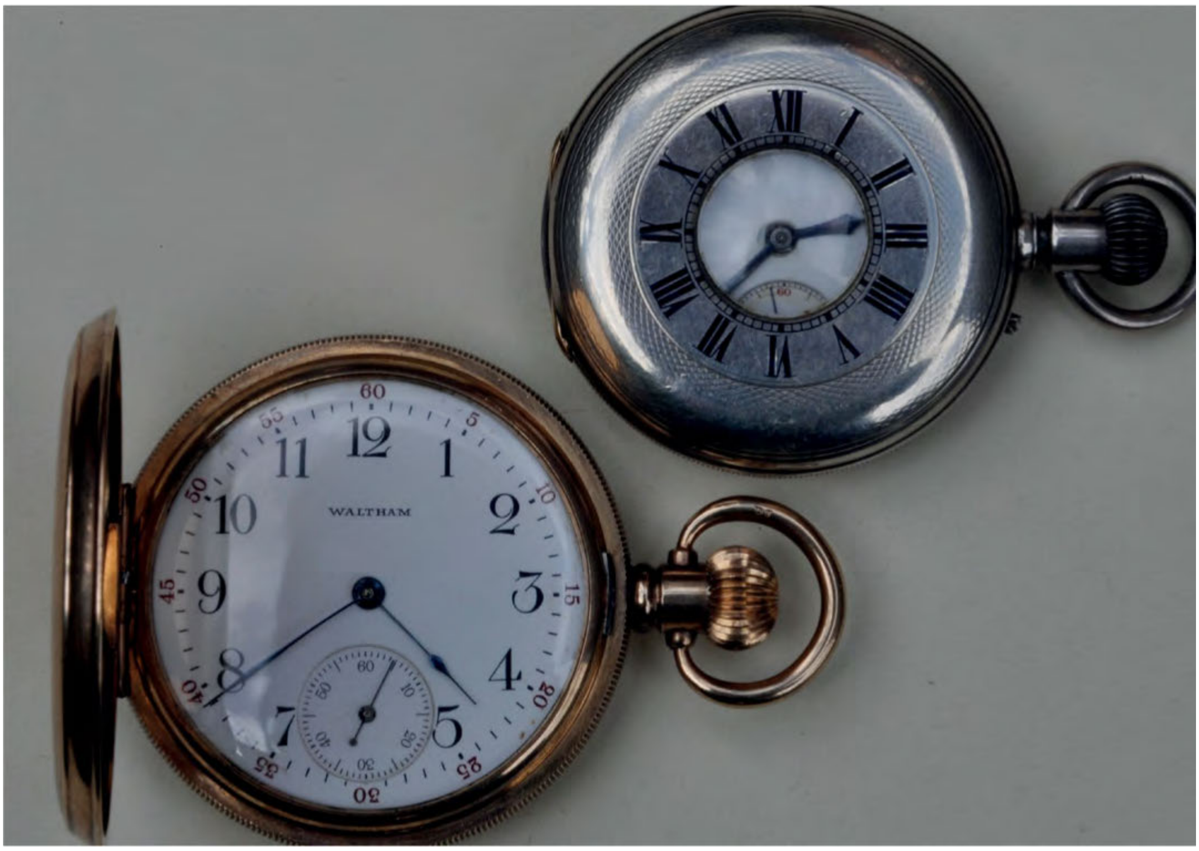
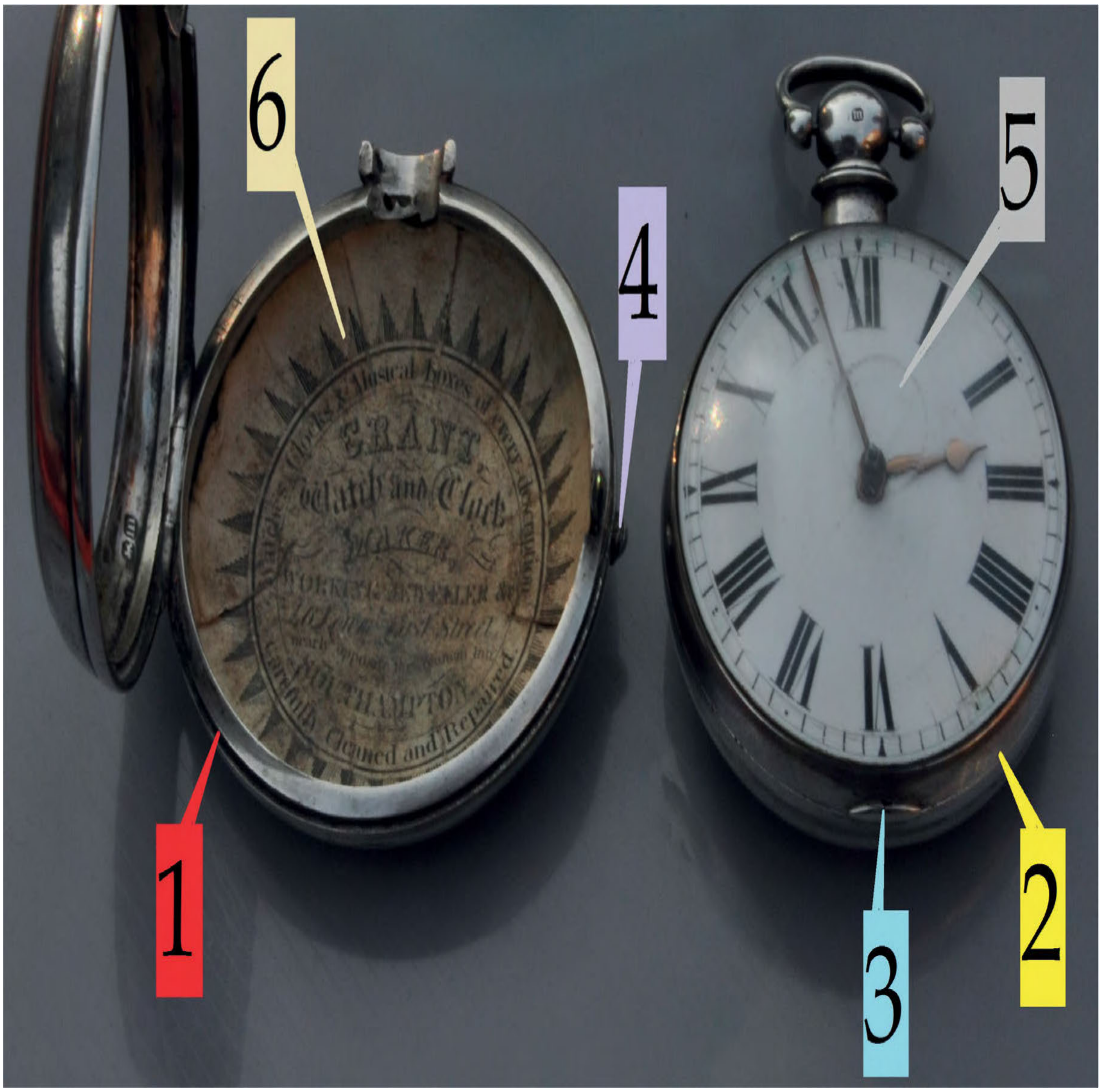


Fig. 22: Hunter pocket watch with the dial cover open revealing the watch's dial.

This is a less common case and one that is more popular with collectors. The case has a door that covers the dial, and this cover is opened by depressing the winding button to release the catch that keeps it shut. In the image you will see a silver protrusion at three o'clock around the periphery/dial; this is the catch. This case type derives its name from hunting. As hunting is a vigorous activity, it was soon found that the glass of an open pocket watch was prone to being smashed – hence the protective cover.

Also the positions of the numbers on the dial are orientated differently from those of the open face pocket watch. This is so that the owner can open the cover and read the dial with one hand, without rotating the watch. Pocket watches were designed to hang on a chain clipped on the bow that surrounds the winding button (or crown) with an open face, on which the time would be read with the crown vertical, so numbers twelve and six would be in line with it. This may not seem so unusual now, as the dial and winder of a modern watch are in the same positions as those of the hunter. Recently, many antique hunters have been converted into large wristwatches.

The half hunter or demi-hunter: This case is almost the same as the hunter case, with one small difference: the cover has a small peephole with a small glass fitted into it. This allows the owner to view the hands without having to open the case.



The Pair Case

Fig. 23: Pair case pocket watch. 1 Outer case; 2 Inner case; 3 Lip used to open case; 4 Push button to open case; 5 Bulls eye glass; 6 Repair papers (service history).

With the pair case we are really in the realm of antique watches; it is probably the least common type of case you will see, and again is very popular with hardcore veteran watch collectors. It is most often seen in eighteenth-century watches, and is where the watch has an outer protective case, which also acts as a dustcover. Why a dustcover? This type of watch is wound by a key, which is inserted in a hole in the back of the main case. However, this hole also allowed dust and dirt into the case and ultimately into the movement, so the second case was the solution to the problem.

This outer case also became a problem, however, as it was quite often lost, and if it were made of a precious metal, it was very expensive to replace.

To open the outer case there is a push button located at 3 o'clock which releases the catch, allowing removal of the case.

WRISTWATCH CASES

Two-piece Watch Case

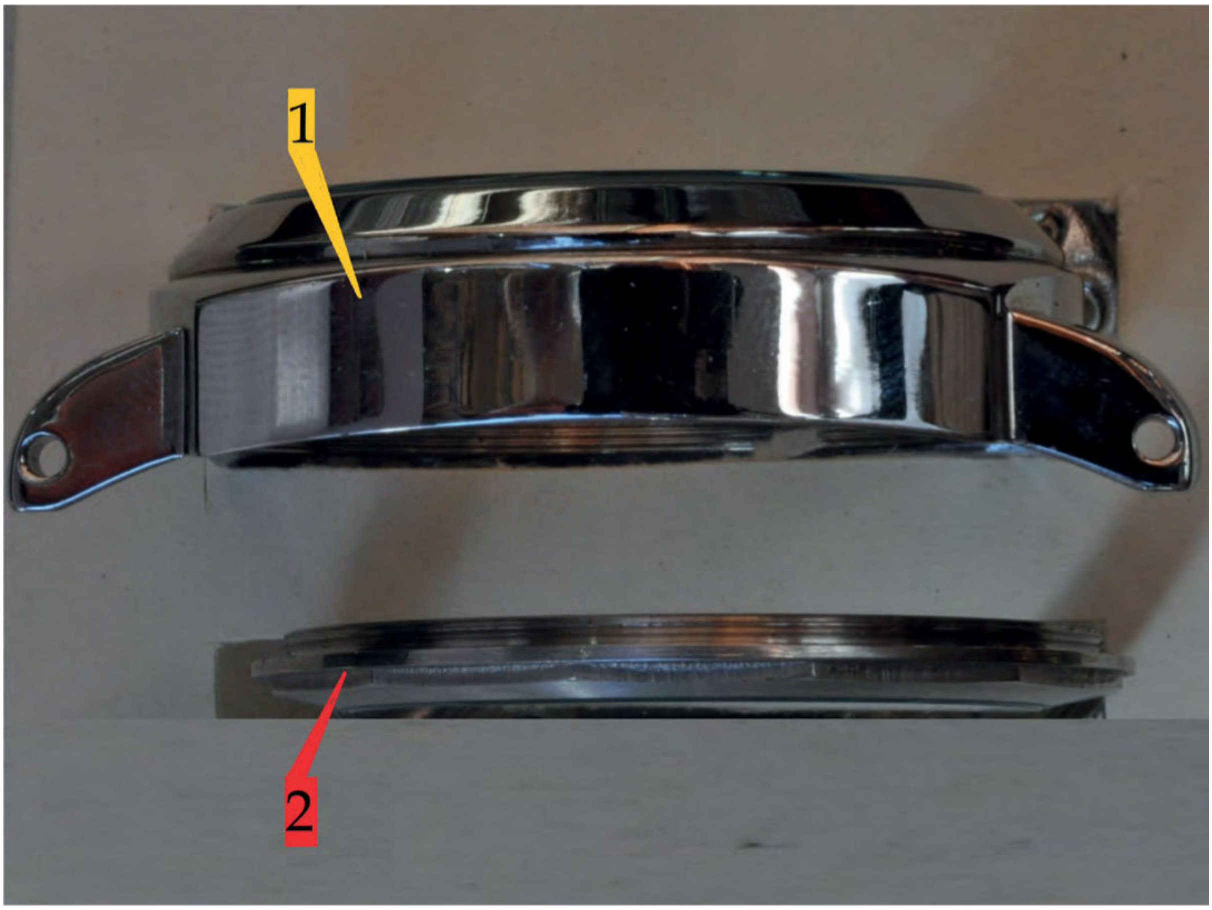


Fig. 24: Two-piece wristwatch case. 1 Case; 2 Case back.

As the name suggests, this type of watch case has two main parts: the watch head (the larger part of a watch case), and the watch case back. This is probably the second most common type of wristwatch case construction available. The movement normally fits into the watch head, then the case back clicks on to the back of the watch head. This is an interference fit, somewhat like fitting the lid of a Tupperware container. With some of the earlier two-piece cases, the construction is reversed, in that the movement fits into the case back, and then the head of the watch cups the back and the movement.

Three-piece Watch Case

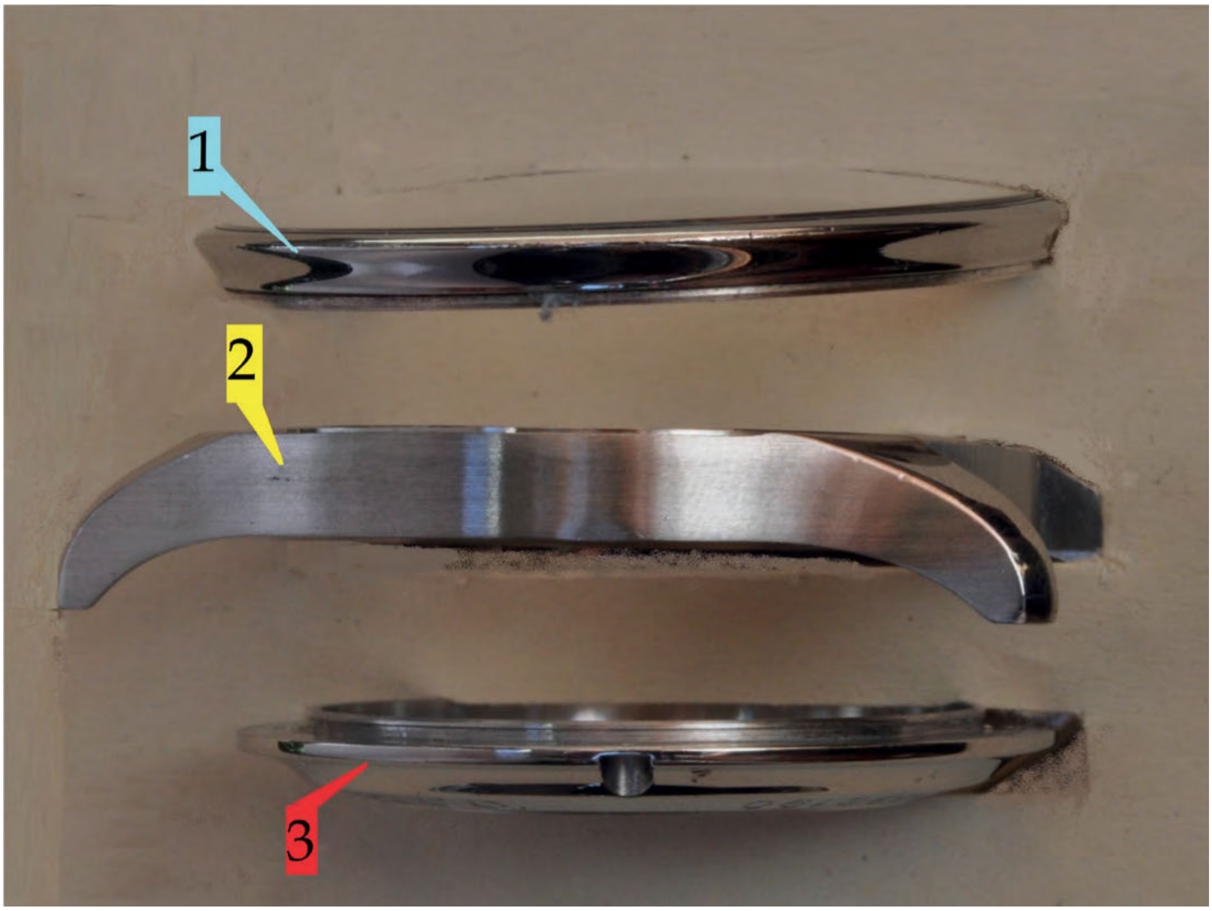


Fig. 25: Three-piece wristwatch case. 1 Front bezel; 2 Case; 3 Case back.

This is probably the modern watch manufacturer's most common case construction. It is essentially the same as the two-piece case, the only difference being in the very front of the watch case that covers the watch face (dial).With this type of case, occasionally the movement cannot automatically be put into or taken out of the back of the watch case in the same way as the two-piece case. It can sometimes be fitted from the front, and the front part of the case (known as the bezel) will then cover the movement and the dial.

One-piece Watch Case

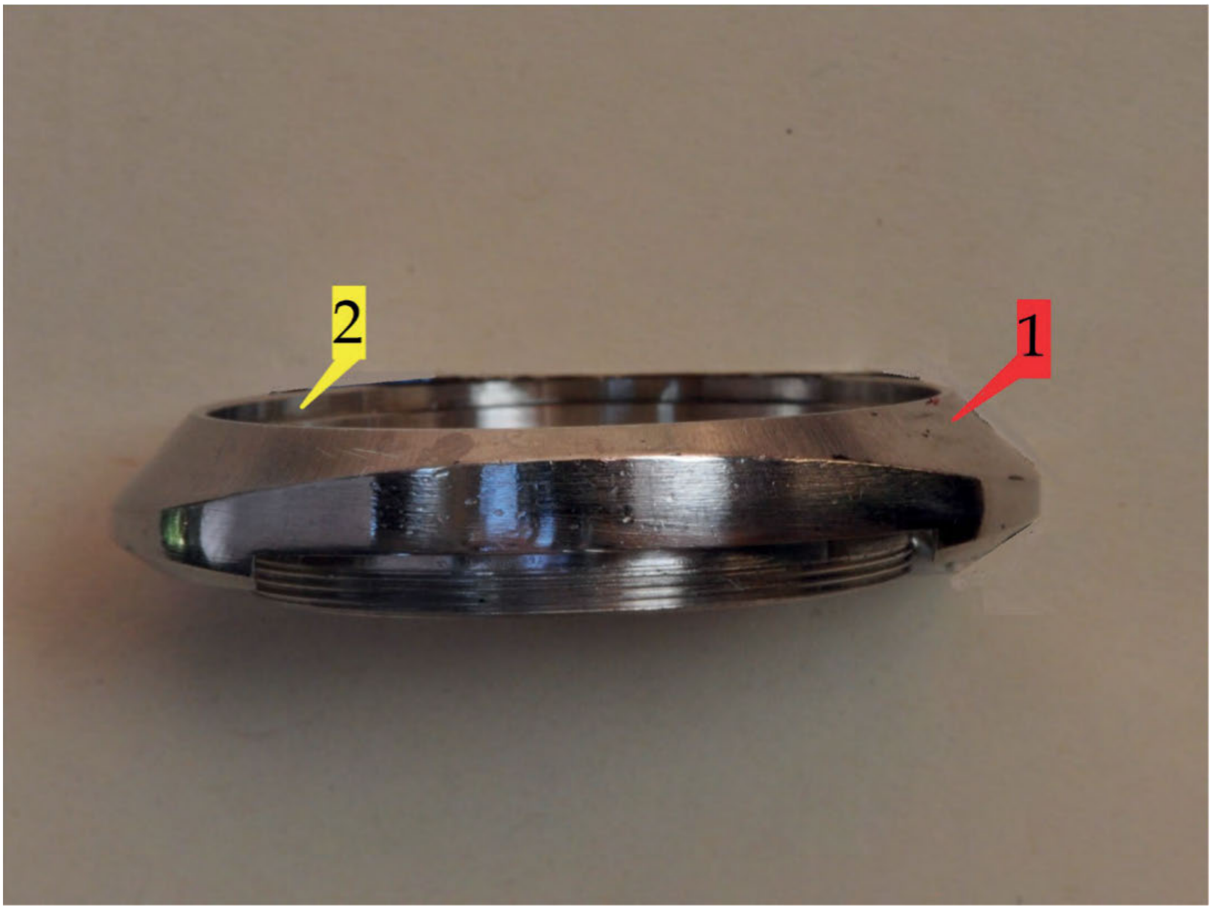


Fig. 26: One-piece wristwatch case. 1 Case head; 2 Glass seating ring.

The one-piece case has no front bezel or back, and the only entry into it is through the hole that the glass fits into. This is a late twentieth-century invention and a fairly uncommon type of case. It can be seen in watches from the 1960s, and Omega adopted this style in their Dynamic range. Later on, this style of case became very popular with gold watch cases, mainly because it lends itself to the casting process, rather than being machined from a solid block of metal, thus saving on metal wastage. When dealing with precious metals this is clearly an advantage.

There are two variations of the one-piece case. The first has a plastic glass that is pressed into the front of the case, giving it the added bonus of making a water-resistant seal. To gain access to the movement, a tool called a ‘crystal lift’ is used. This tool has twelve or more claws that close round the glass, and as the tool is tightened, it squeezes the outer edge of the glass to compress it to make it small enough to be removed.

The second is a case that has a mineral glass. This first appeared in the 1970s, and can been seen in the Omega Seamaster Cosmic range. The glass is pressed into a plastic washer, which holds it firmly in the case. To remove the glass a controlled stream of compressed air must be fed into the watch case through the pendant tube after the crown has been removed. The beginner is probably best advised to avoid this type of case. If this type of watch is handled carelessly, the dial and hands can be damaged beyond repair.

Trench Watches

'Trench watch' is a name given to a broad style of watch, and is also a name recently coined by collectors. A trench watch is a military wristwatch from the early 1900s, normally with a leather strap fixed to the case by wire lugs, or more traditionally a watch with a red number twelve on the dial, or numbers that have been filled with luminous paint. The back normally opens up like a pocket-watch case with a hinged back, but it opens at 9 o'clock instead of 6 o'clock.

To open the back of the watch there is normally a protrusion at 2 or 5 o'clock, and it can be opened easily with a fingernail or a case knife. The front part of the case (the bezel) is removed in a similar fashion with a case knife. If there are no protrusions there will be a very small cutout that the knife blade can be pressed into.

Borgel Cases

This is another trench watch, but the case is put together in an entirely different way. It was designed in an attempt to try and make the watch more robust against the elements (dust and moisture), as clearly the battlefield wasn't the best place for a watch. The main part of the case is a cup that the movement dial and front bezel screw into. In essence, this is the first screw-together case, invented by François Borgel in the late 1800s. It is normally recognized by the fact that there is no removable case back, and the front bezel has a milled edge to it similar to that found on a pound coin.

To gain access to the movement, first pull out the winding button into the hand set. Keeping a constant pull on the button, rotate the front bezel in an anticlockwise direction until the movement screws out. To refit, pull on the button on the empty case and screw the movement back into the case.

6. OPENING AND REFITTING WATCH CASE BACKS

POCKET-WATCH BACKS

Pocket-watch cases come with three varieties of back: snap-off, hinged and screw-on.

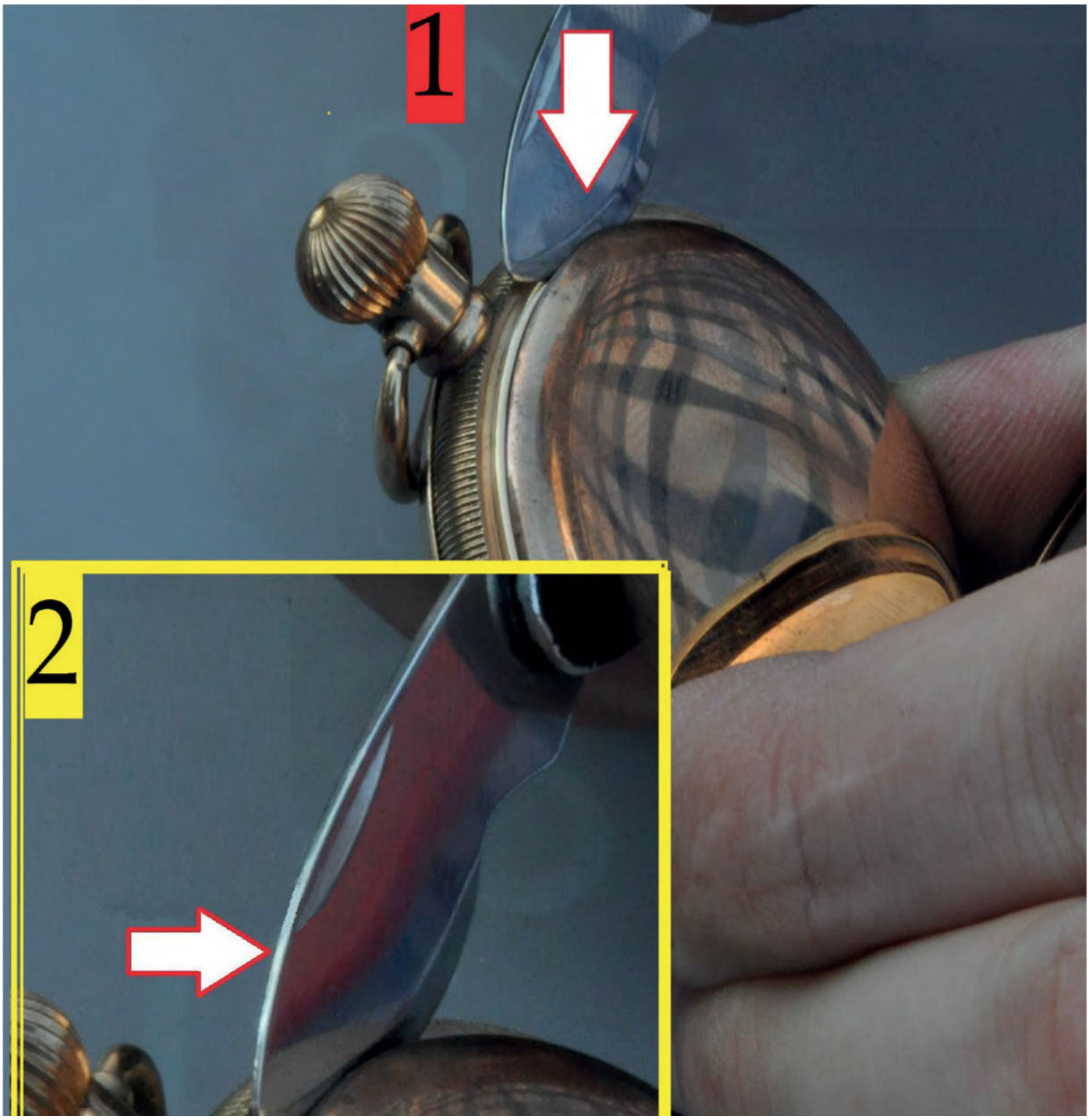


Fig. 27: Opening a snap-on case back: in image 1 a case-knife blade is pushed into the case cut-out; in image 2 the case knife is twisted to pop open the back.

Snap-off backs: This type of back is a percussion fit, somewhat similar to a Tupperware container, and is normally opened with a watchmaker's knife. This is the most common type of watch case on the market, and normally associated with cheaper watches.

Hinged backs: These are the same as the snap-off type with the addition of a hinge, so once the case has been opened the back will remain attached to the main body of the case (like the glove box in a car or the lid of a piano).This type of case is very common with pocket watches; it is also found in early wristwatches from the 1900s, and is normally found in a watch made from precious metal such as gold or silver.

Screw-on back: These are the same as wrist-watch cases where the back screws on to the main body of the watch head. The only slight difference is that you will sometimes find that the front bezel will also screw on to the watch head, unlike a wristwatch case where you will normally find a screw back with a snap-on front bezel.

Opening a Pocket-Watch Back

To open a hinged or snap-off pocket-watch back, first inspect the side of the case with an eye glass and look at the back for a line where the back meets the body of the case. Looking carefully at this line you should see a small slot or a raised bump at 2 o’clock. Insert the case knife, making sure that the flat side of the blade faces the body of the watch and the curved part of the blade faces the back. Push in towards the dial, keeping the knife horizontal with the case. By using an eye glass, you will see the knife blade slides into the case as you exert pressure on the blade, and you will feel the blade hit the inner rim of the case body. If you are holding the blade in your right hand, twist the knife anticlockwise and this should pop off the back. This will also ensure that the blade does not fly into the movement.

Once the back has been opened, the chances are that you will be presented with another back: this will be the dustcover, and it is opened in the same way. The dustcover is a throwback from the earlier watches that were wound with a key. It would have had two holes placed so that a key could engage with a winding square to wind the watch without revealing the movement, thus keeping the dust out. The other hole was used for setting the hands.

Pocket Watches with a Screw Back

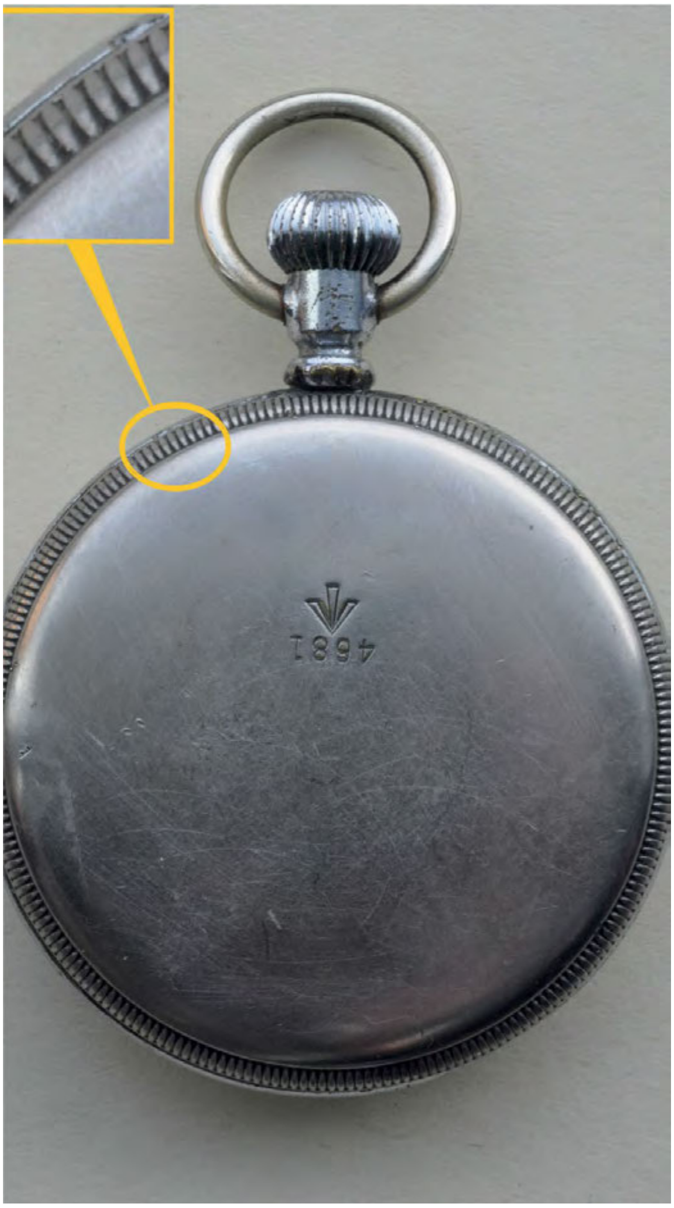


Fig. 28: A military pocket watch with a screwed-on case back. The milled edge commonly found on this type of case back is highlighted.

Screw backs are fairly uncommon amongst English and European watches, but our American cousins on occasion made one or two. The likes of Elgin and Waltham are most often to be found with screw backs, and also sometimes screwed-on bezels. But a note of caution here, as this type of case has occasionally caught out the unsuspecting watchmaker, and it is always best to have a really good look at a case before you run in and cause havoc. As you become more experienced, you will begin to recognize quite easily the differences between a snap-off back and a screw back. There is not currently, to my knowledge, a tool to open pocket-watch screw backs.

To spot a screw-back pocket watch you will normally find that the outer edge of the back will have a milled edge, similar to the milling found on the edge of a pound coin.

Opening a Screw Back

To open a pocket watch with a screw back, place the watch in the palm of your left hand face down. With your right hand, press your palm down on the back of the case and twist your right hand anticlockwise. If the case is very tight, you may have to vary the amount of pressure when squeezing the case between your palms to loosen it. Once loose, unscrew it to remove with your fingers. Care must be taken with the glass with regard to pressure, and only you can decide whether or not it will stand the pressure of your palm bearing down on it. If the glass is original to the watch, they are normally quite thick. I personally have never had one break on me, but that does not mean that you will be as lucky as I have been. (I didn’t make these watches!)

WRISTWATCH BACKS

Wristwatch cases come with three varieties of back screw-on, secured by screws, and snap-on.

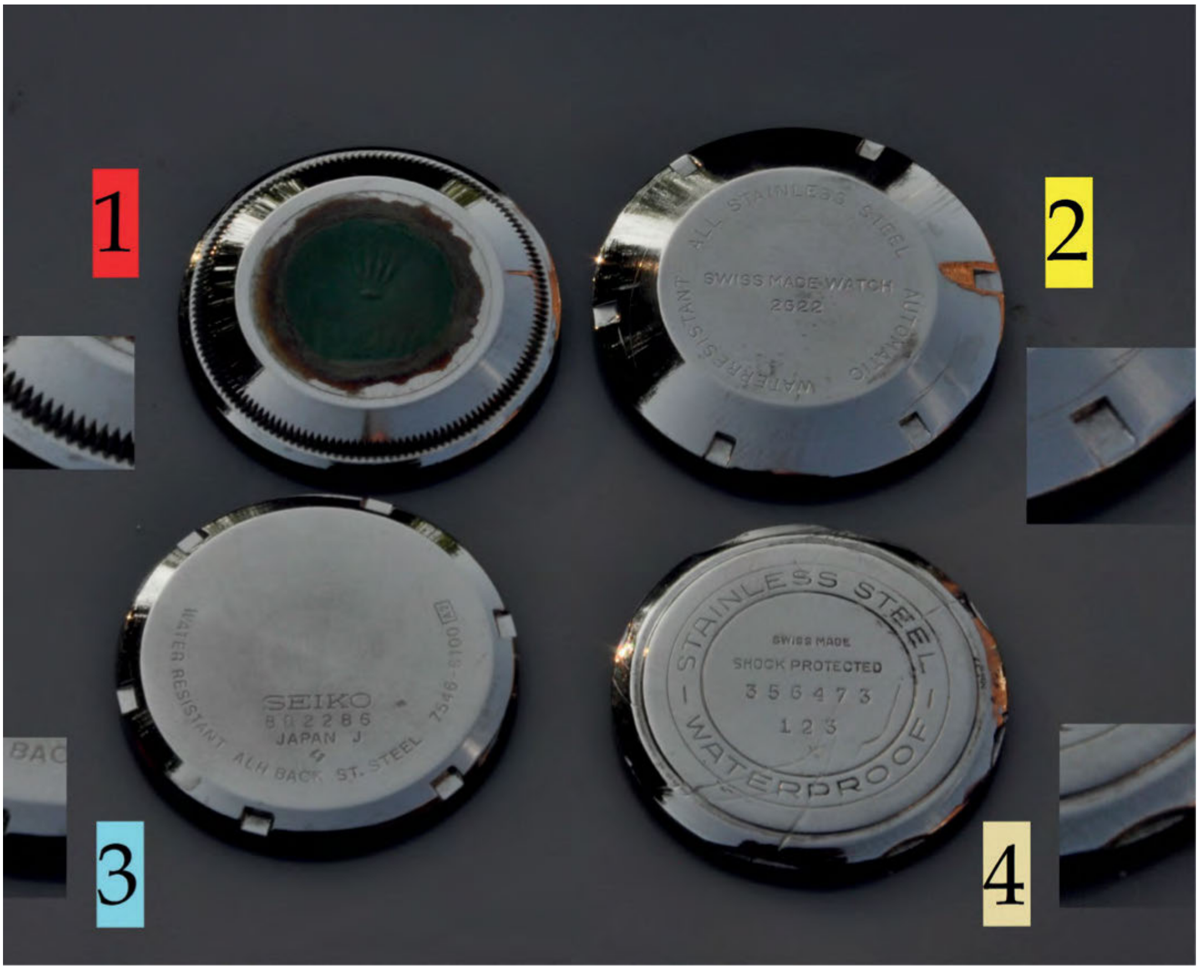


Fig. 29: Four common types of screw back found in the trade: image 1 is a Rolex case back, identified by the milled edge. Images 2 and 3 are very much the same and are also the most common. Image 4 is more commonly seen as hexagonal, but this one has little scalp cut-outs. All these backs are opened with a type of key or socket, or a multi-tool such as the Jaxor case opener.

Screw backs: These backs are exactly as they sound, in that the back of the case unscrews, in the same way that a bottle top unscrews from its bottle. This design lends itself to water-resistant watches, used for extreme water sports or diving. This is due to the fact that the screw back can be torqued up tight to create a watertight seal with the aid of a washer (called an ‘o’-ring seal) as seen in Fig. 26, part 1.

Back secured by screws: This type of watch back is secured to the case by four or more screws. It is commonly found in shaped watch cases that require better water resistance, or a fancyshaped case that might be impractical for a snap-on back. You will sometimes find three-piece cases with screws holding the front bezel in place as well.

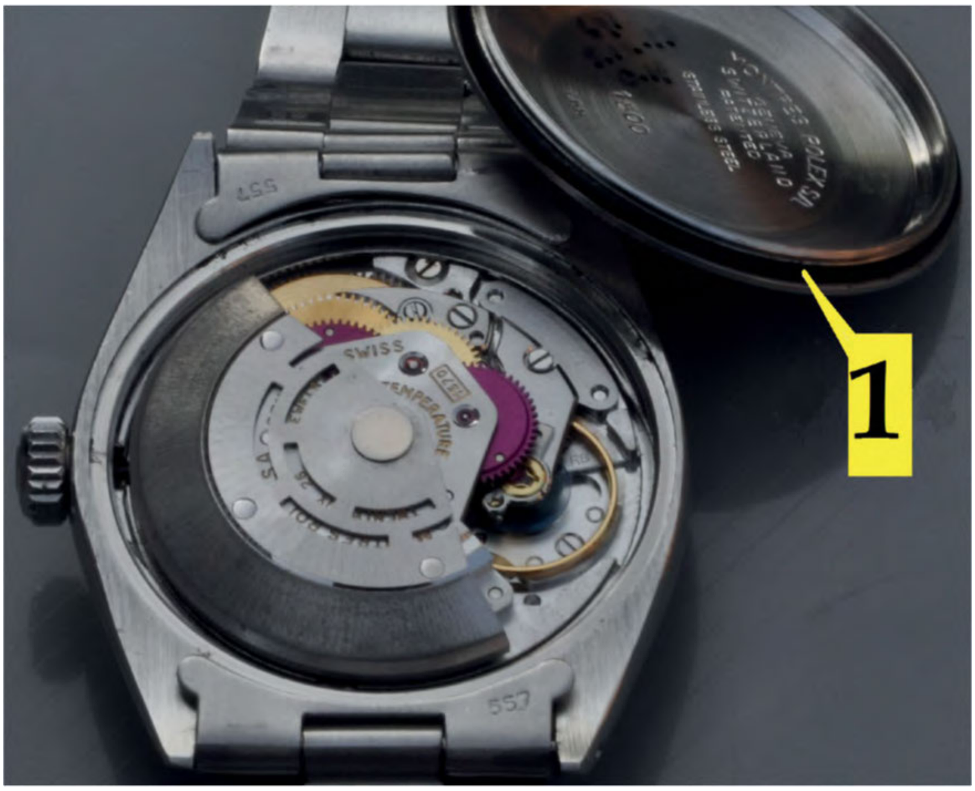


Fig. 30: Rolex with its back removed, to reveal the black rubber seal (1) that is used to make a water-resistant seal between the case back and case when the two parts are screwed tightly together. Also shown is the screw thread on the case back and the inside of the case.

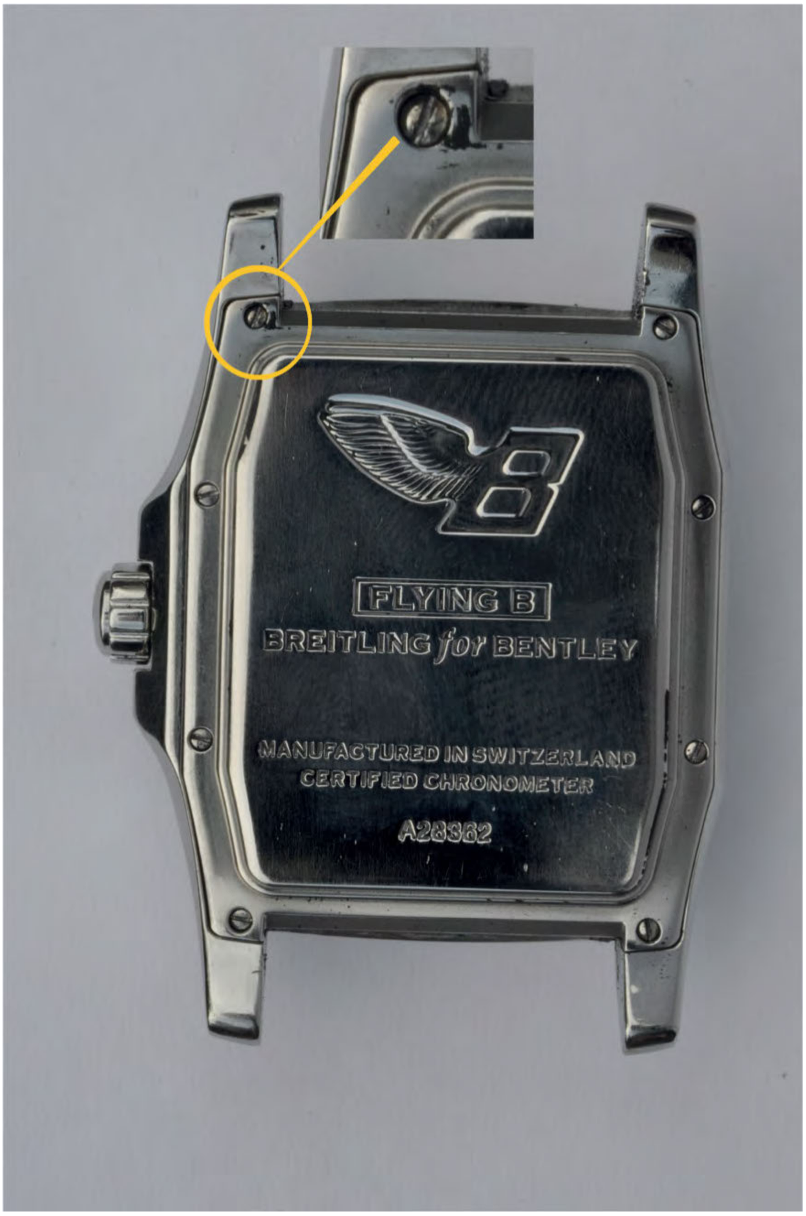


Fig. 31: A watch with a back secured with stainless-steel screws (to prevent rust), normally found on watches made by various fashion houses.

Wristwatch Snap-on Backs

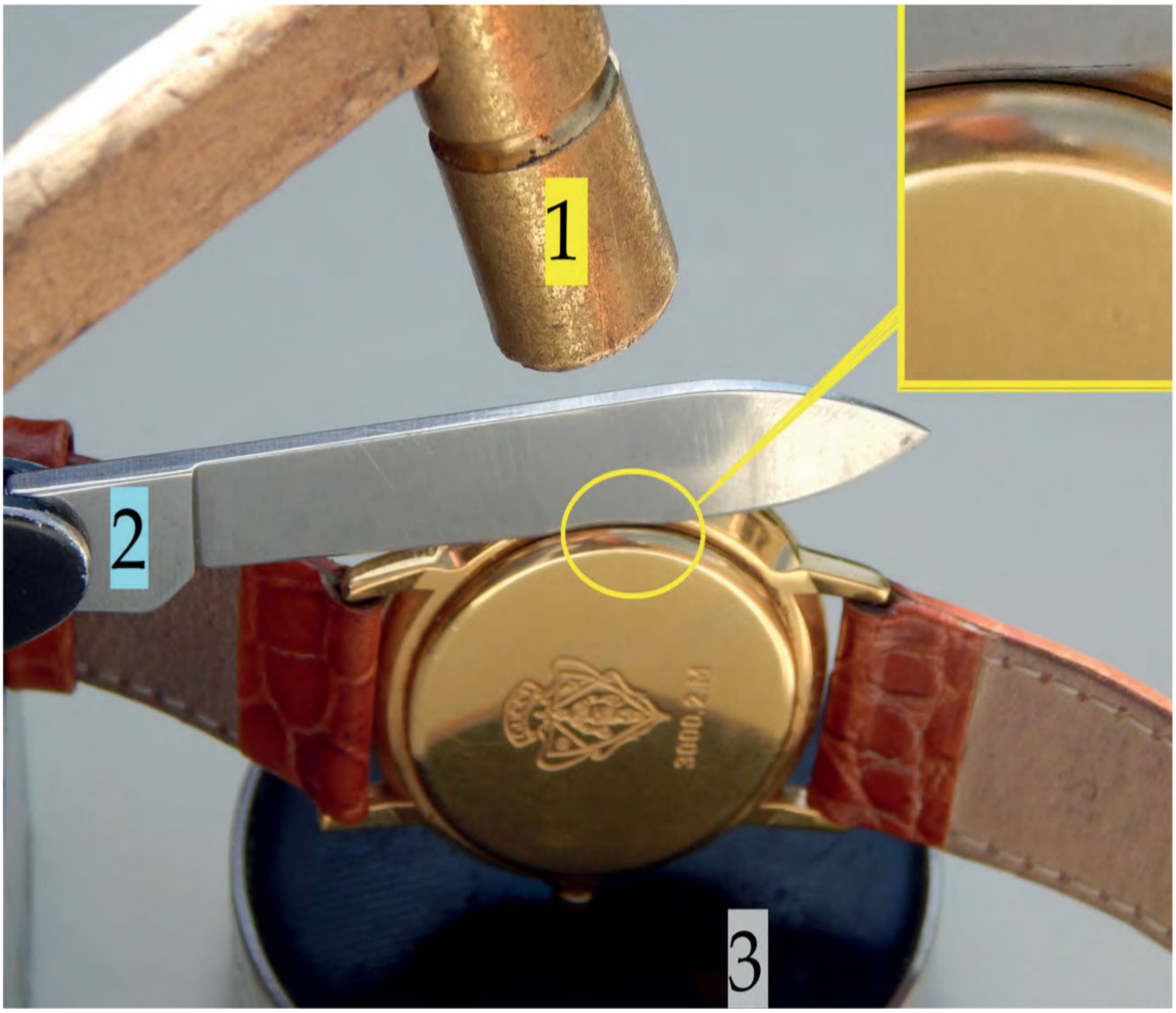


Fig. 32: To open a stubborn snap-on back, first rest the side of the watch on a casing cushion (3). Gently tap a sharp blade (2) into the case cut-out (if present) using a brass hammer (1) – brass is best, because if you were to hit the case there is less chance of marking it. Once the knife is tapped into the side of the case, twist the blade to pop off the back. Take care using this method on gold and gold-plated cases as they are very soft and easily damaged.

Opening a Snap-on Back

Snap-on backs are normally completely smooth with no cutouts or serrations. They are opened in the same fashion as pocket watches, the only difference being the position where you have to insert the knife; typically you will find that the cutout has been moved to 9 o'clock, as the dial orientation of the case has changed – and this will apply to the front bezel as well, if it is a three-piece case. It is, however, becoming more common for watches to be opened at 12 or 6 o'clock, or even to have some sort of notch in line with the lugs on the case (the lugs are the bars on to which the strap is fixed – see 'Warning' below). Some watch companies leave an extension of metal, or what looks like a lump on the edge of the back, to aid in opening the case. This tends to give you a bit more metal to slide your case knife under, thus reducing the chances of the knife slipping and scratching the back.

Warning: If the knife cutout is in line with the lugs you must refrain from levering on the lug itself. This is especially true if the lugs are quite thin, as there will be a strong chance that the lug will not be strong enough to take the strain of you levering on it.

If you do find that the back of the watch is particularly stubborn, in order to avoid damaging the case, I would strongly recommend that you take the watch to a reputable watchmaker, who would undoubtedly be willing to remove the case for you.

Refitting a Snap-on Back

This type of back normally has a small semi-circular notch cut into the rim of the back (the part that enters the case) to allow clearance of the part of the winding button that enters inside the case. Special care should be taken when refitting the back to make sure that the cutout is in the correct position, because if incorrectly fitted, the back may snap off the winding stem. An indication of whether the back is straight or not is sometimes helped when the back has manufacturer engraving: this can be used as a guide, by lining it up with the button at 3'oclock.

Closing a Snap-on Back

This can sometimes be achieved by using your fingers, by applying pressure to both sides of the case and localizing this pressure to the edge only, so as not to bend the back or adversely applying too much pressure to the glass, causing it to shatter. If this fails, you can locate one part of the back in the case so that the back is half clipped back on, then, holding this half in place, at the same time rest the other half on the edge of your bench and apply gradual pressure to the unclipped part of the case. This should be followed by a sharp snap sound.

Again, I would strongly recommend that if you do find yourself faced with a particularly stubborn refit, you should take the watch to a reputable watchmaker so as to avoid any unwanted damage to the case.

Closing a Tight Case Back

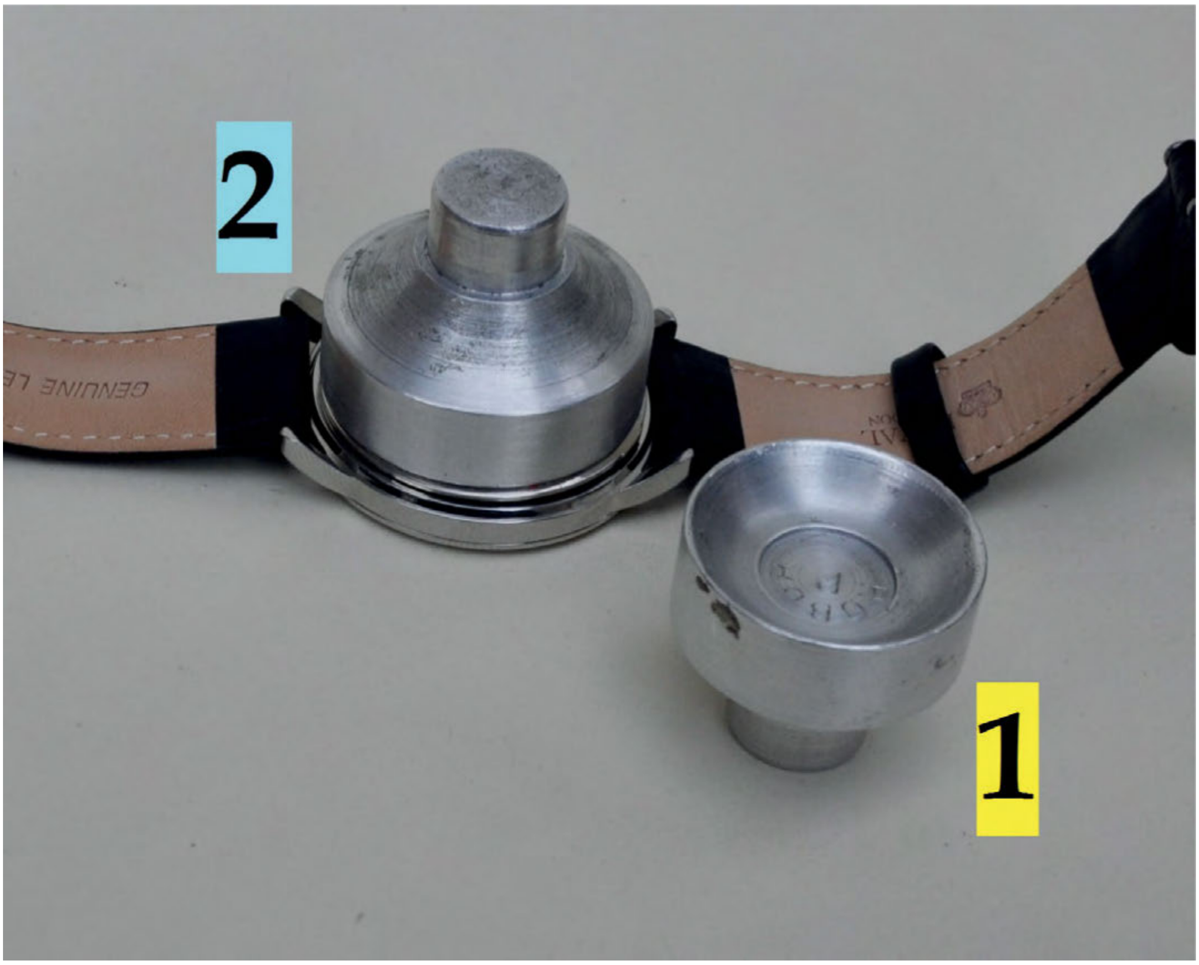


Fig. 33: A set of dies (image 1) commonly found in any glass or case press set, typically made from either brass, aluminium, Bakelite or plastic. Image 2 shows a correctly selected die that covers as much of the back as possible.

If you are going to repair a number of watches you will need some type of glass press. These can be picked up quite cheaply from second-hand tool dealers or on internet auction sites. Alternatively, you can buy one from new. Bergeon make a good tool – the 5500A, while Robur make a slightly cheaper tool, which I personally prefer. Both can be costly to purchase new. These tools, as the name suggests, are great for fitting watch glasses but they are also brilliant for fitting tight watch press-on case backs (fitting watch glasses will be covered a little later on). The tool tends to come with a set of dies in a box, or placed on a board.

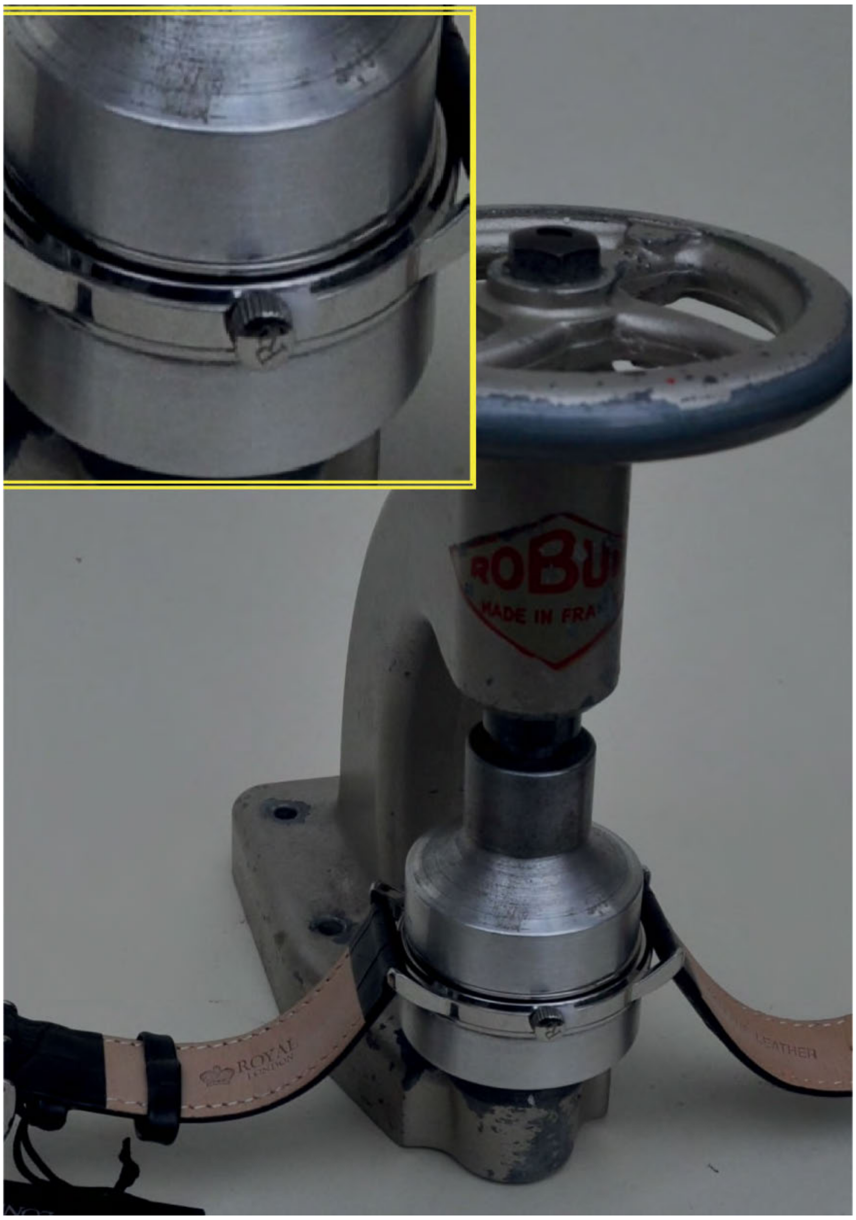


Fig. 34: A case back being pressed back on the watch case, using the Robur tool and two correctly selected dies: one supports the front of the case, and the second presses on the outer edge of the case back.

Fitting the Back

To fit a back on to a watch, first find a die that covers as much of the surface area of the case head around the glass as possible. This is placed in the bottom of the tool, and the watch is placed on top of this die. You now need a second die, slightly smaller (by no more than 1–2mm) than the diameter of the case back. This die goes in the top of the glass press. The case back is then placed on the watch, which should be placed face down on the bottom die. Take care if the lip of the watch back has a cutout for the winder, and place it accordingly to avoid damage to the winder. You now either press down on the handle, or turn it: this will move the two dies closer to each other. Continue until either you hear a slight click, or you feel that the back has snapped closed.

Opening Early Wristwatches

Early wristwatches sometimes have a hinged back, the same as pocket watches. Often this early type of wristwatch has a slight lip added to the edge of the case, so that the back hinged cover can be opened with your thumbnail. Also, once opened, you will be presented with a second cover, the dustcover. This will open at 4 o'clock and will also be hinged. Again, this second cover is a throwback to the days of pocket watches.

Opening Square and Oblong Snap-off Backs

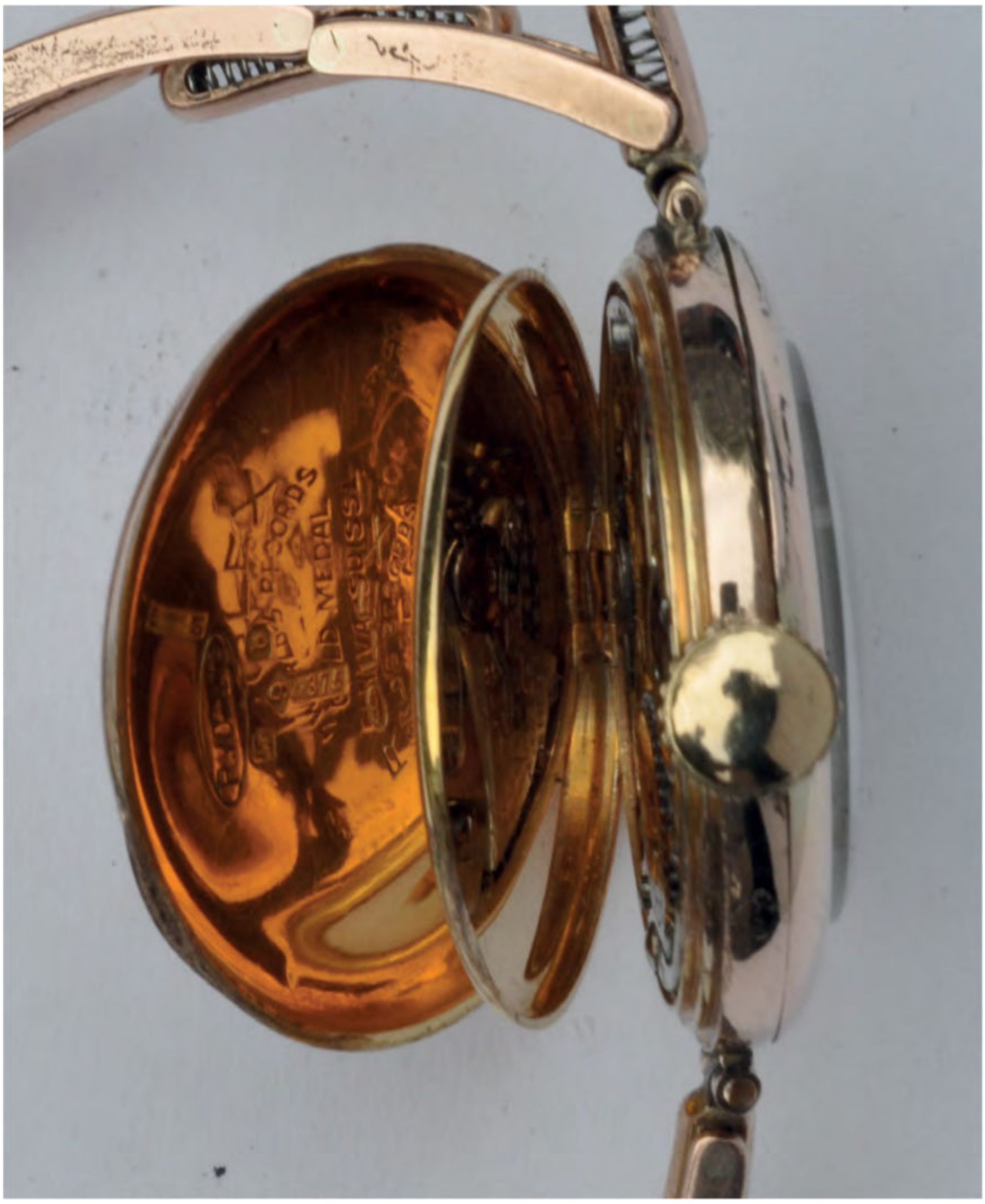


Fig. 35: A watch case from the 1920s with a hinged inner dustcover and case back.

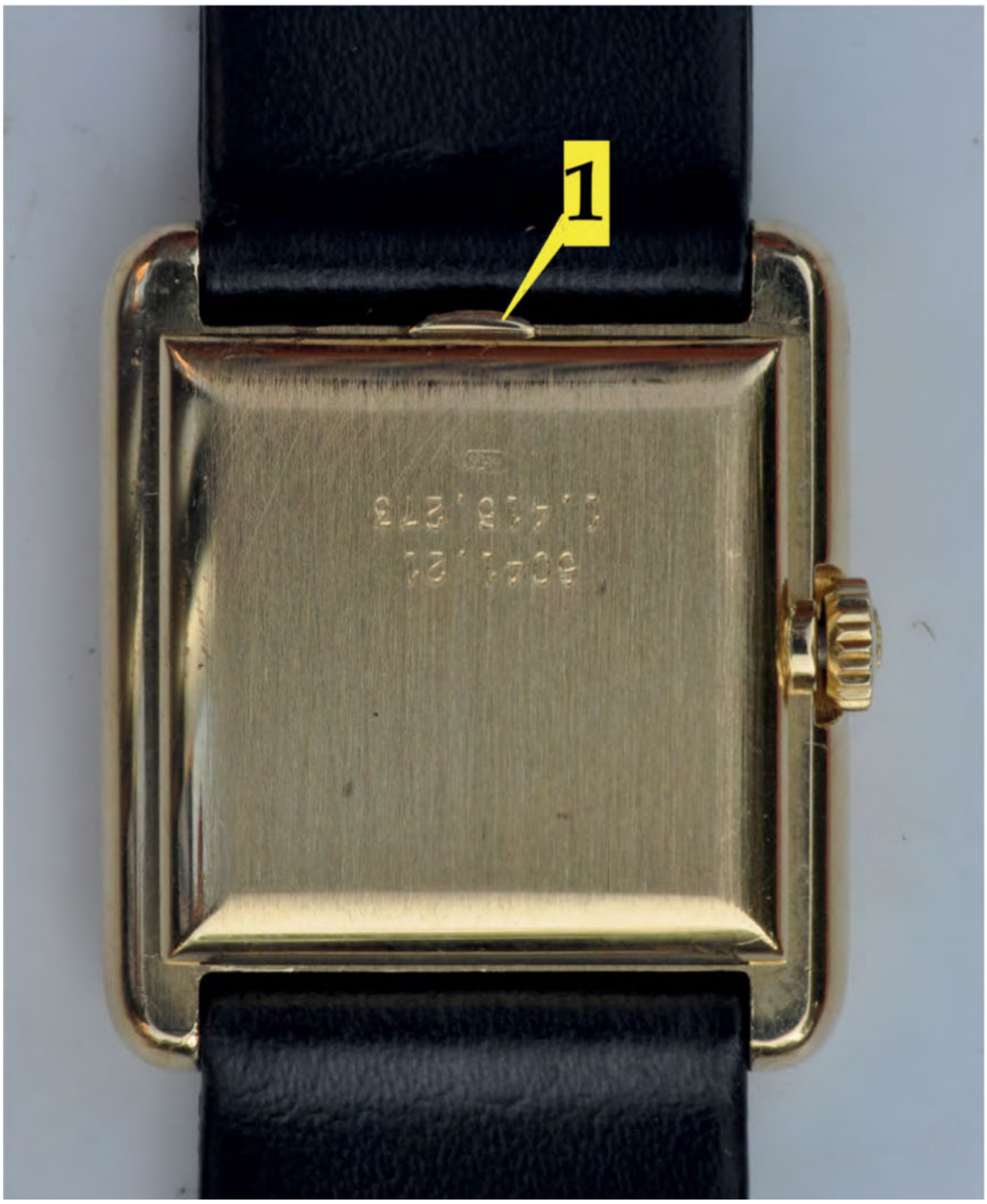


Fig. 36: A case with a lip (image 1), which is used to lift off the case back.

Typically, watches from the 1920s will also have a hinged back, so you must first locate the hinge to determine which side to lever up with your case knife. It may not even be necessary to use a knife, as a fingernail will normally do the job. Modern cases will generally have an extended lip added to the case to help lift off the back.

Opening Wristwatch Screw Backs

To open this type of case will require a case spanner, a suction-type opener or a bench-mounted case opener. (As described in the first section, pocket watch cases can be easily opened without any tools normally by simply sandwiching the case between your two palms and twisting your hands in opposite directions, making sure to turn the hand pressing on the back to be removed in an anticlockwise direction.)

There are several types of wristwatch screw back, and each watch manufacturer will have a special key or die to open their cases. The proper tool for the job is obviously best and also safer to use, while at the same time limiting the chances of marking the case. Unfortunately these tools can often prove very difficult to obtain, as most watch companies will only supply them to their service centres. There are, of course, some generic tools on the market, but the quality of these varies from good to useless. However, it is possible to make do with a universal case opener. The most common of these is the Jaxor case opener mentioned earlier; this will open the large majority of cases, and is the best tool to buy to start with. You will no doubt in the future end up purchasing one or two of the more specialized after-market tools for the likes of Rolex, Brietling, Paneri, Baume and Mercier watches. (This may indeed be far in the future, so is perhaps something to put on your birthday list.)

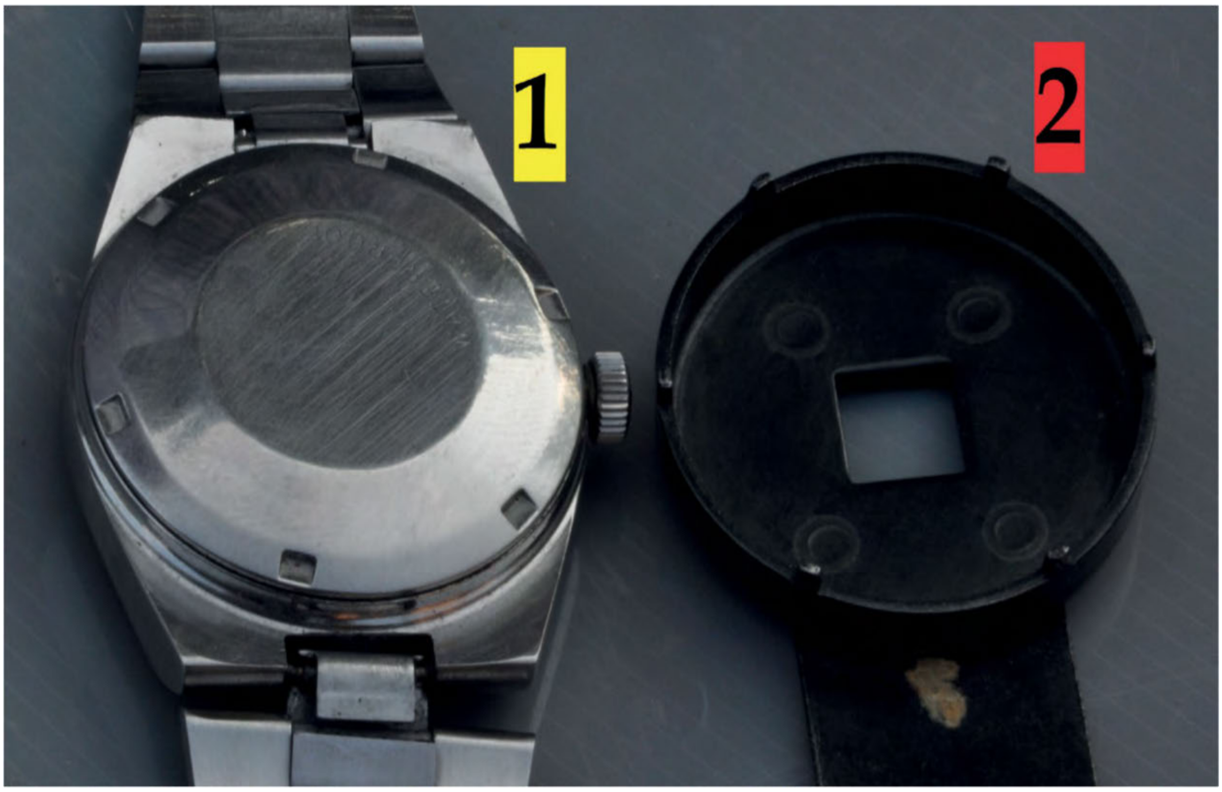


Fig. 37: A vintage Omega watch (image 1) with a screw-back case. Image 2 shows the correct spanner that is used to open and close this type of watch.

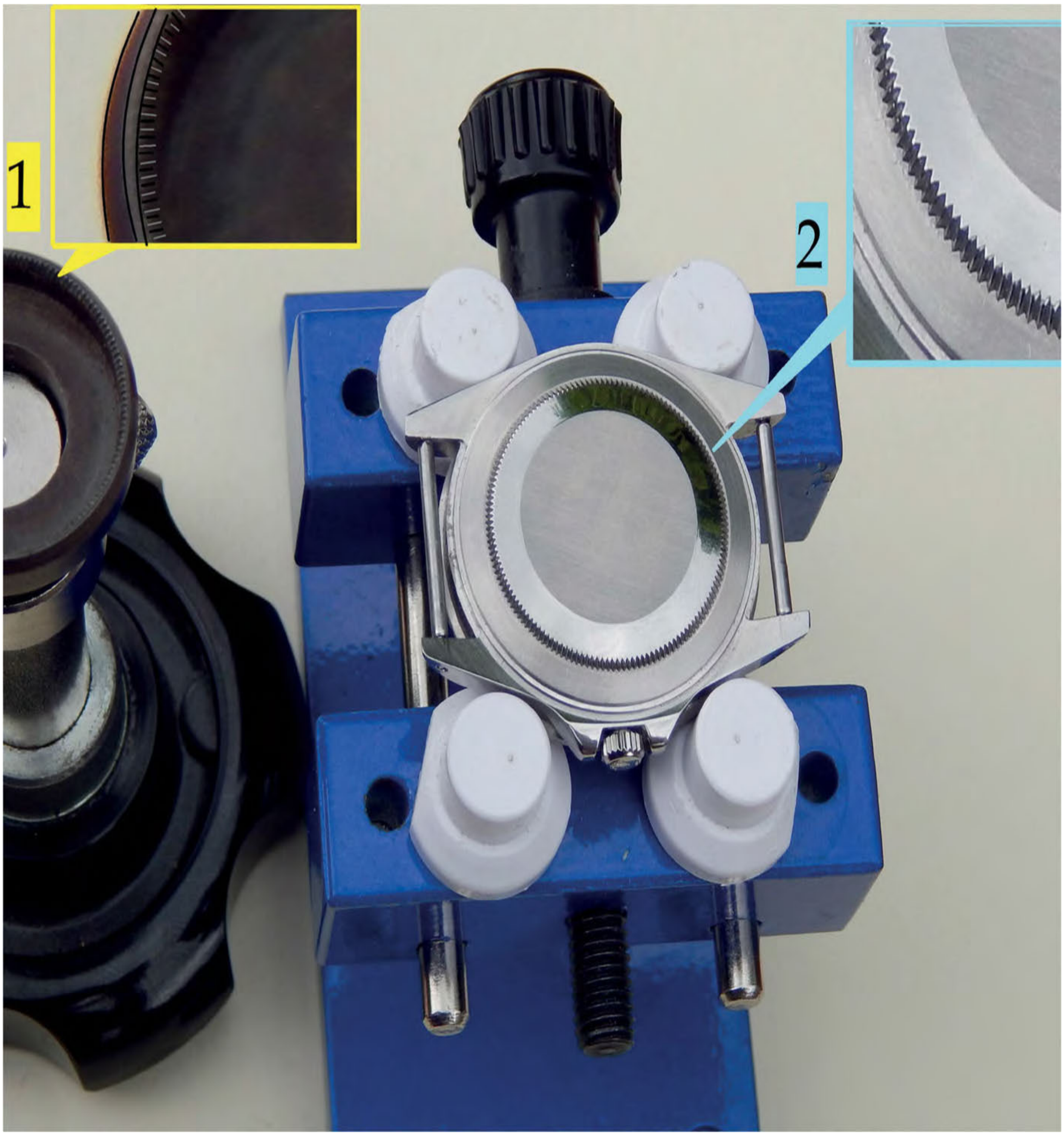


Fig. 38: Image 1 shows the die or socket used to open a watch with a Rolex-style back. Image 2 shows the watch case held in a case vice (or holder), typically used when opening screw-back watches.

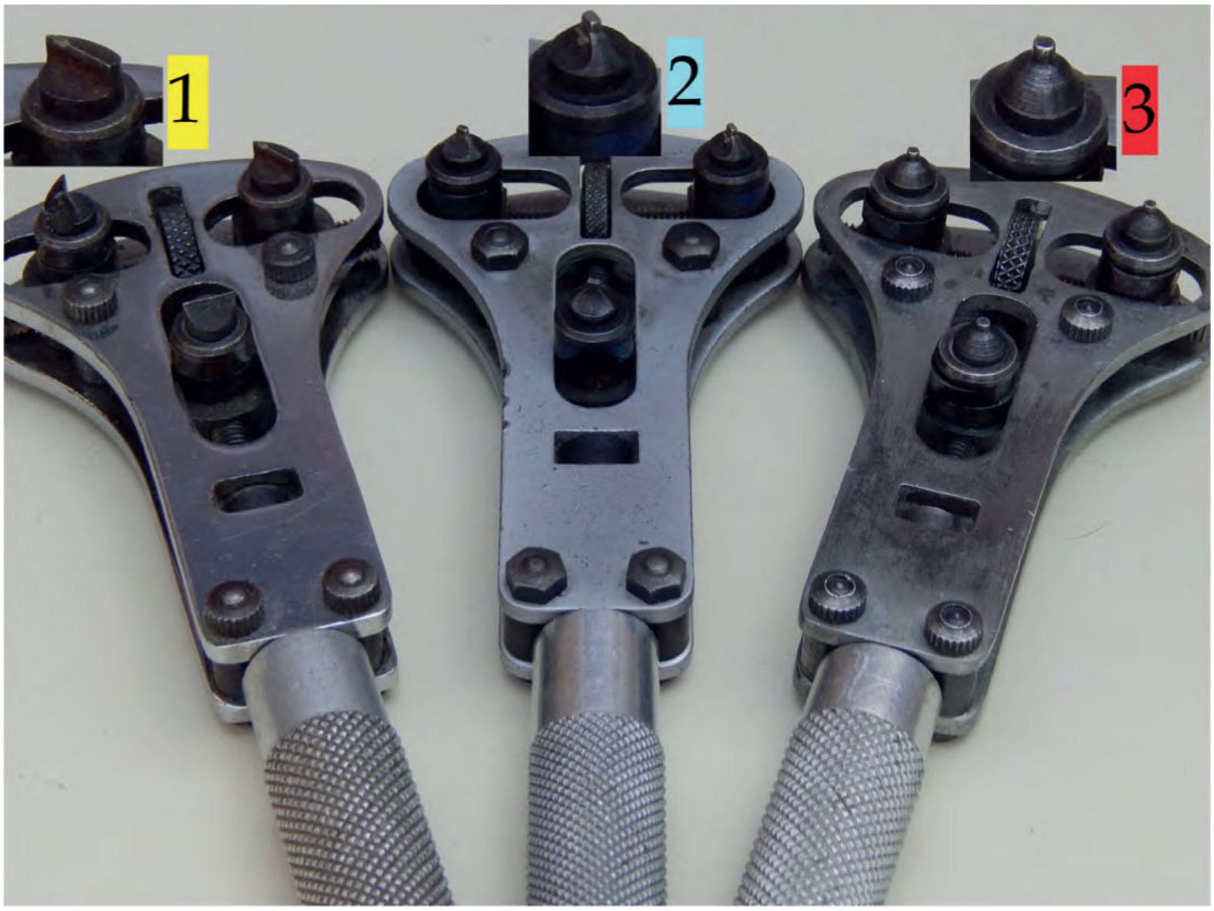


Fig. 39: The Jaxor tool fitted with three different styles of toolbit. In image 1 it is used for watches with hexagonal case backs; in image 2 it is used for backs like that of the Omega in Fig. 37, with square or oblong cut-outs. In image 3 it is used on backs with scallop cut-outs, as seen in Fig. 29.

Screw-back cases also come in a variety of shapes, and each manufacturer has their own system. In layman's terms a screw back is basically a nut, and the tool is a wrench with a socket to fit the nut. To open a screw-back case, it is wiser to remove any bracelet it might have, as this will only get in the way and may become twisted during removal of the back. Next you will have to find the toolbits that fit the holes or serration in the case back. Hold the case in one hand, and adjust the tool so that the jaws fit into three evenly spaced holes (or sides if it is a hexagon-type back). Once you are sure that the tool is securely fitted to the back, apply some downward pressure to the tool to make sure that it doesn't slip out of the back, as any slip will permanently damage the back. Proceed to turn the tool, keeping downward pressure in an anticlockwise direction to loosen the back. Once loosened, remove the tool from the back; you will now only need your fingers to remove the back.

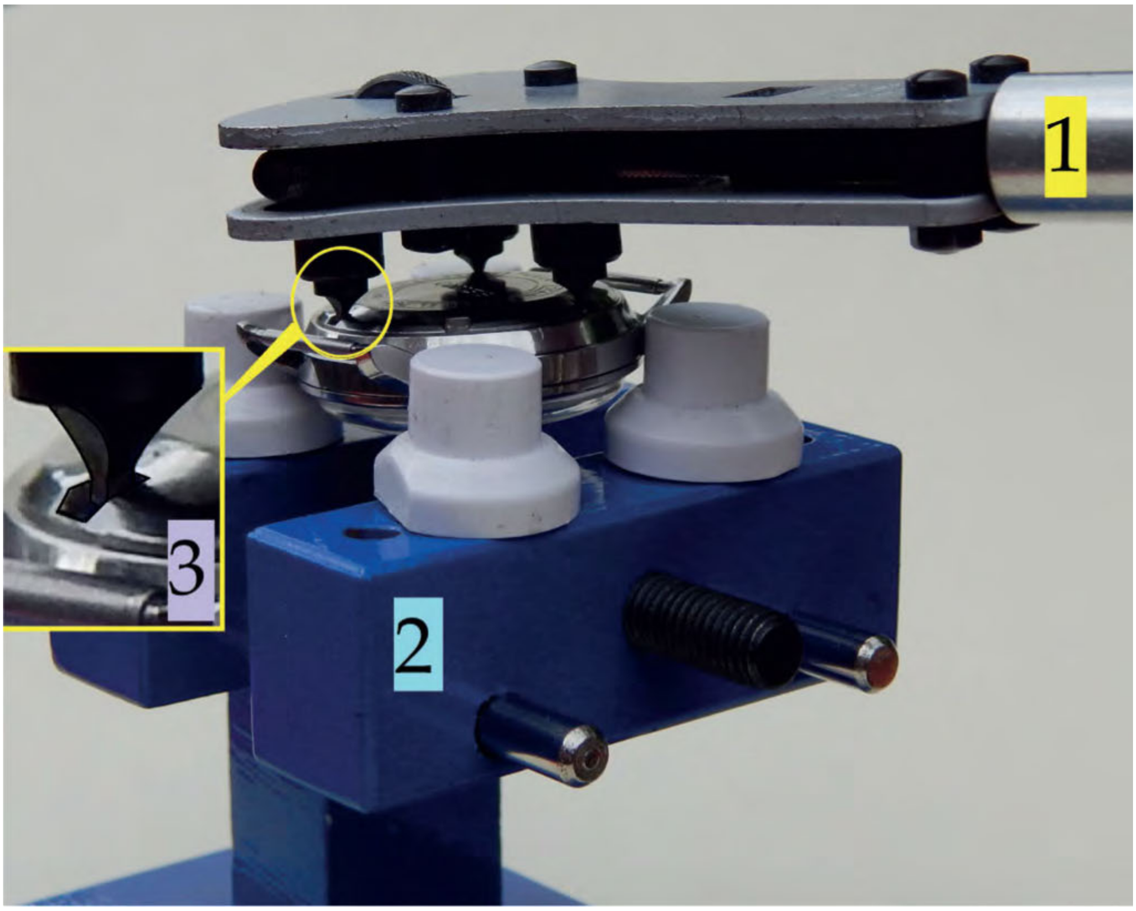


Fig. 40: A Seiko being opened with the Jaxor tool. Image 1: the case is held secure in the case vice or holder. Image 2: the three toolbits are evenly spaced around the case back and seated into the slots in the case back. Image 3: the tool is used like a spanner to remove the back.

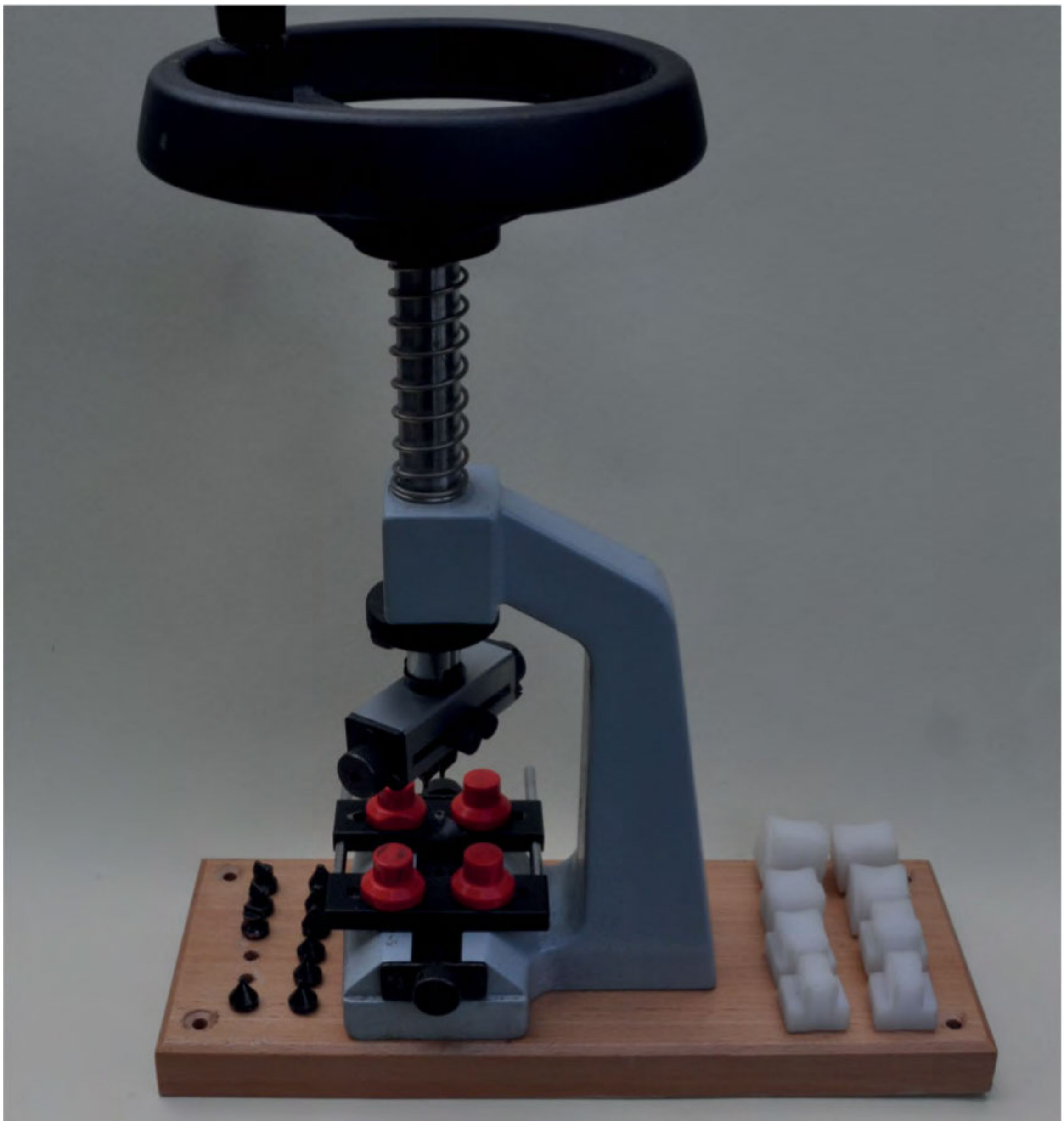


Fig. 41: Bergeon 5700 case opener.

Alternatively, if this proves to be excessively hard due to an overly tightened back, then use a case holder, if you have one. This is a slightly safer method of removing the back (most of my students buy these thinking that they are movement holders). Case holders like this are normally made of plastic with movable support jaws, having pegs that can be moved into various hole combinations. The most efficient type of case opener is the Bergeon 5700, although other companies such as Horotec make a similar version.

7. REMOVING AND REFITTING STRAPS AND BRACELETS

All watches have some type of strap or bracelet fitted to them, and at some point you are going to have to remove and refit them to the case. This is a relatively easy task, but there will always be the occasional strap that will put up a fight. It is very important to use the correct tool for the job as it is easy to mark any watch case and hard to remove the marks, without very expensive equipment!

The tool I recommend using is a spring bar tool, and there are various tools on the market. I have tried several over the years and Bergeon's 6767S is the best that I have used thus far; the steel quality is very good, and the cheaper versions of this tool tend to wear out very quickly, or bend. You can opt for the slightly cheaper version, but keep away from the tool with the black plastic handle as the blades on this tool are far too thick. If you are intending to work with watches as a hobby or part-time job, or are just collecting, it's always a good idea to have an assorted box of spring lugs to hand.

The majority of watch straps are fixed to a watch's case with some sort of telescopic springloaded bars called spring lugs. These locate into small holes on the inside of the watch's lug. These can be blind holes (Fig. 42), which are half drilled through the lug, or drilled all the way through the case lug (Fig. 43).

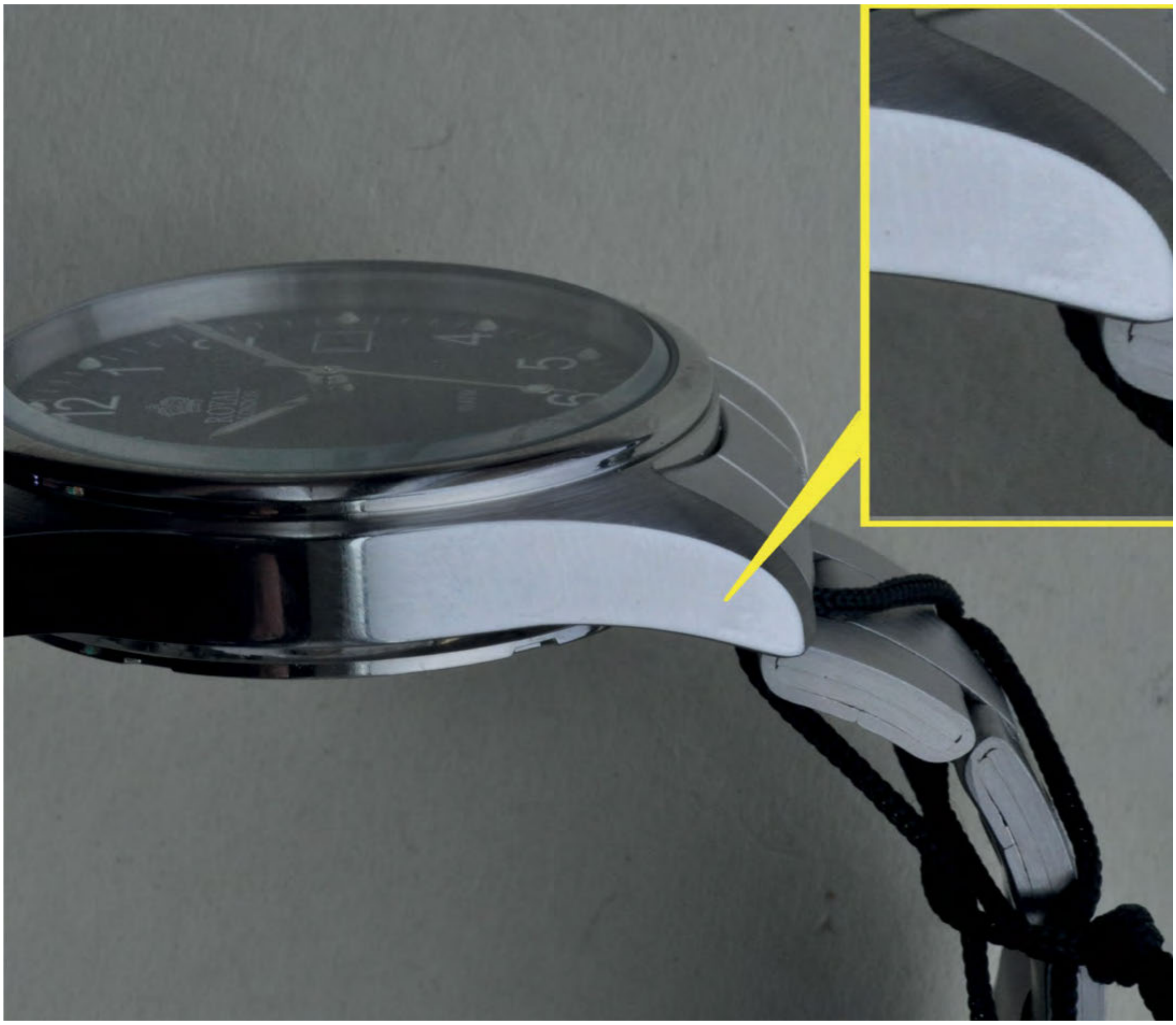


Fig. 42: A watch case with a blind case lug hole.

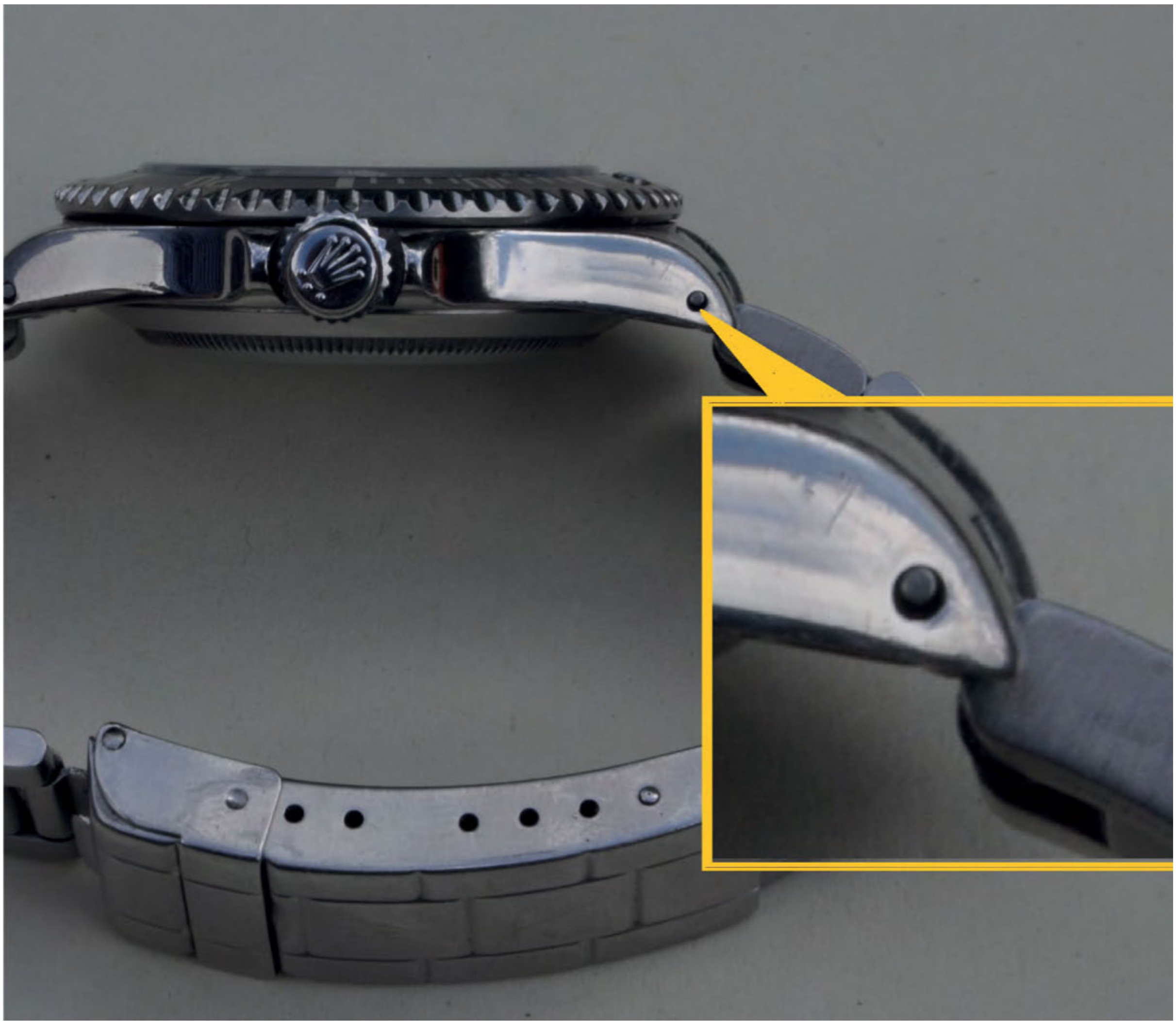


Fig. 43: A watch case with a drilled lug hole.

SPRING LUGS

Spring lugs come in a variety of styles and sizes, and are the most usual device for fixing a strap to a watch case. The ends of the lug are spring-loaded and telescopic, so they can be compressed in order to remove and fit them in a watch case or bracelet.

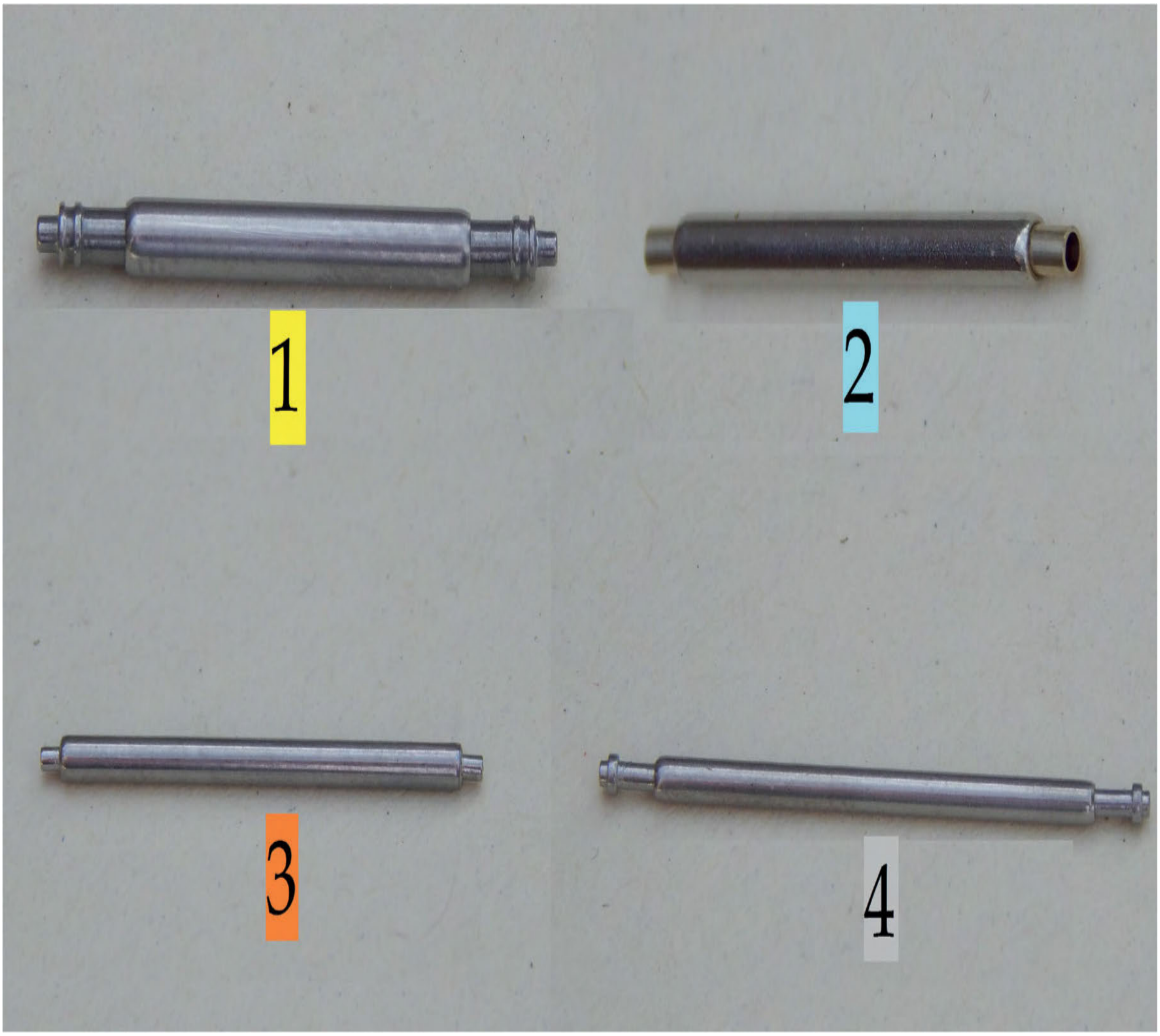


Fig. 44: Image 1: double-flanged spring lug. Image 2: female spring lug. Image 3: a spring lug used inside the watch clasps. Image 4: single-flanged lug.

Double Flange and Single Flange Spring Lug

(See image 1.) The double flange is the most commonly used of the spring lugs, and they are commonly sold in four diameters: 1.80, 1.50, 1.30 and 1.0mm. These all come in widths of 6mm, ranging up to about 46mm. The flange is the raised lump on the near end of the lug, and these help you remove them from a case. I personally hate the single flange lugs, as I find them much harder to remove from the case once fitted; with the double flange you can stick the 'V' end of the strap tool in the middle of the two flanges, and this helps retract the end of the spring lug out of the hole of the watch case.

With the single flange lug, the flange will be hard against the case making it hard to insert the ‘V’ end of your tool in between the case and the spring lug. I tend to replace a single flange lug fitted to a blind hole case with double flange lugs, to try and keep things easier in the future. It is acceptable to fit the single flange lug into a watch case that has opened drilled holes, as you can use the pin end of your tool to remove them easily.

When buying spring lugs, remember that they are graded into sizes according to the size of the strap, so if you are fitting an 18mm strap you will be fitting an 18mm spring lug, and this will really be about 20mm in total length.

Single Shoulder Spring Lug

(See Fig. 44 image 4.) This type of spring lug is typically used in leather watch band buckles. They are removed by using the pin end of the strap tool, inserting it into the holes in the side of the buckle. These lugs are usually found inside the clasps of bracelets, as the ends are much shorter than that of the flanged spring lugs, and they won’t poke through the sides of the clasp. There is also a single flanged spring lug that is used on bracelets, but this has a shortened end called a shortened bead.

Tip: Never fit a single shoulder spring lug (see Fig. 40 image 4) on to a watch case that has a blind lug hole, as you will never be able to remove it from the case! If you ever make this mistake the only way to remove the lug is by cutting it out of the case using a piercing saw with a very fine jeweller blade.

Female Spring Lug

(See Fig. 44 image 2.) This type of lug is now quite obscure, but I have included it as it catches out a lot of people. It is normally only fitted to older gold dress watches from the 1950s and 1960s, as some of the older delicate lugs were so thin they couldn’t have the lugs drilled to accommodate a standard spring lug. These spring bars have hollow ends on each tip. They are still compressible and will fit over a pin that sticks out between the lugs.

FIXED LUG WATCH CASES

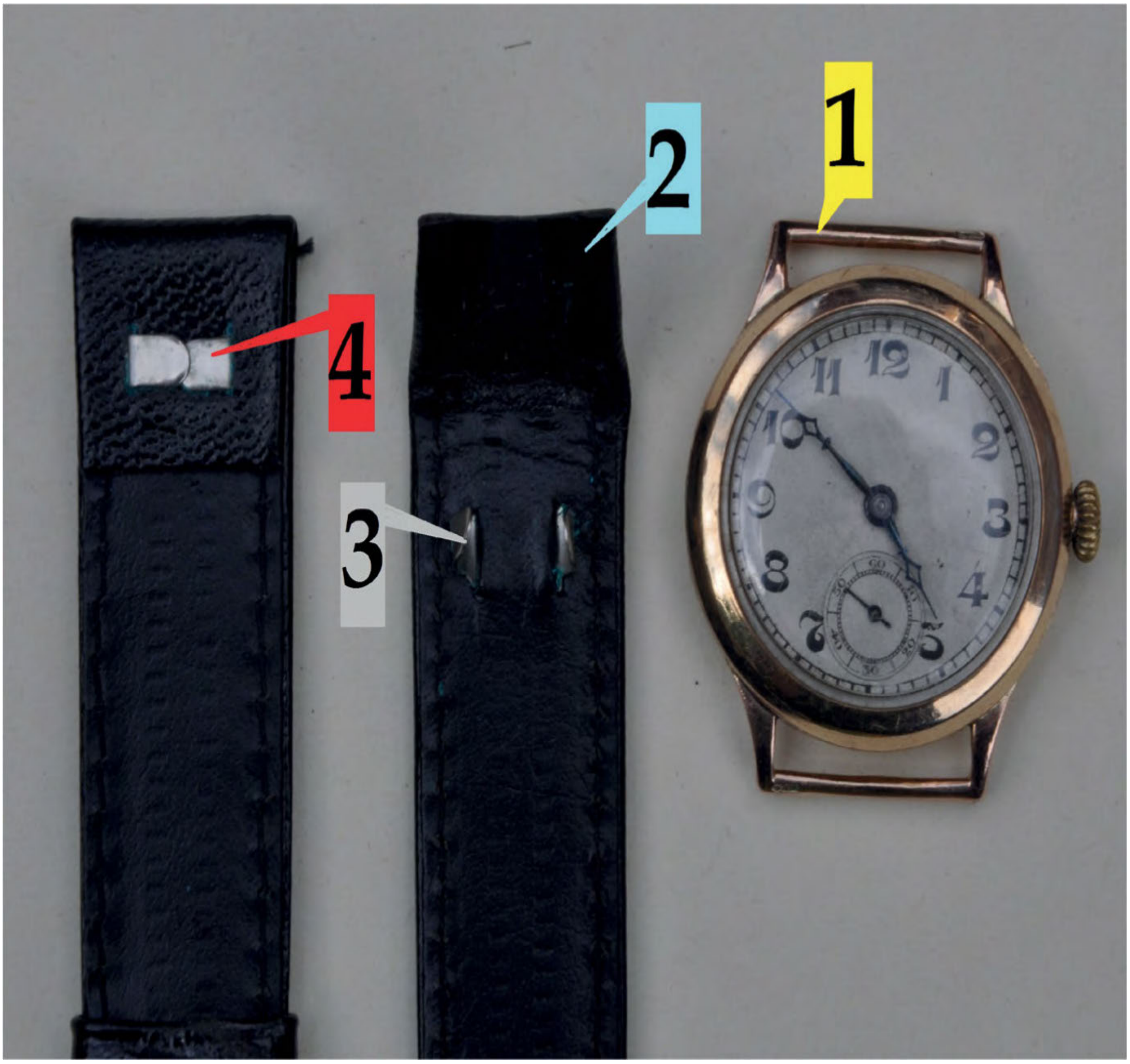


Fig. 45: Image 1: an early wristwatch with fixed bar lugs. To the left is the strap that fits this sort of watch, known as a 'unifix'. This strap has a flap (image 2) and two metal tabs (image 3). Image 4 shows the strap folded over and locked in place with the tabs.

This type of case has a solid bar that is fitted to both ends of the case, where a solid strip of leather or silk is threaded though the wire lugs. This is the original way of securing a strap to a watch case when wristwatches first appeared. It has become common now to refer to this style of watch as a 'trench watch'.

The leather straps that fit these cases are called 'unifix', and have an open flap with two holes. About 1cm down from the flap are two metal tabs that are fixed to the main part of the strap.

The flap wraps around the fixed lug, and the two tabs pop in the holes of the flap and are then bent over to secure the strap.

The more modern type of this strap has open flaps that are not stitched or glued, and the flap is wrapped around the fixed lugs. The ends are just glued to the main part of the strap.

REMOVING A STRAP OR BRACELET WITH BLIND HOLES

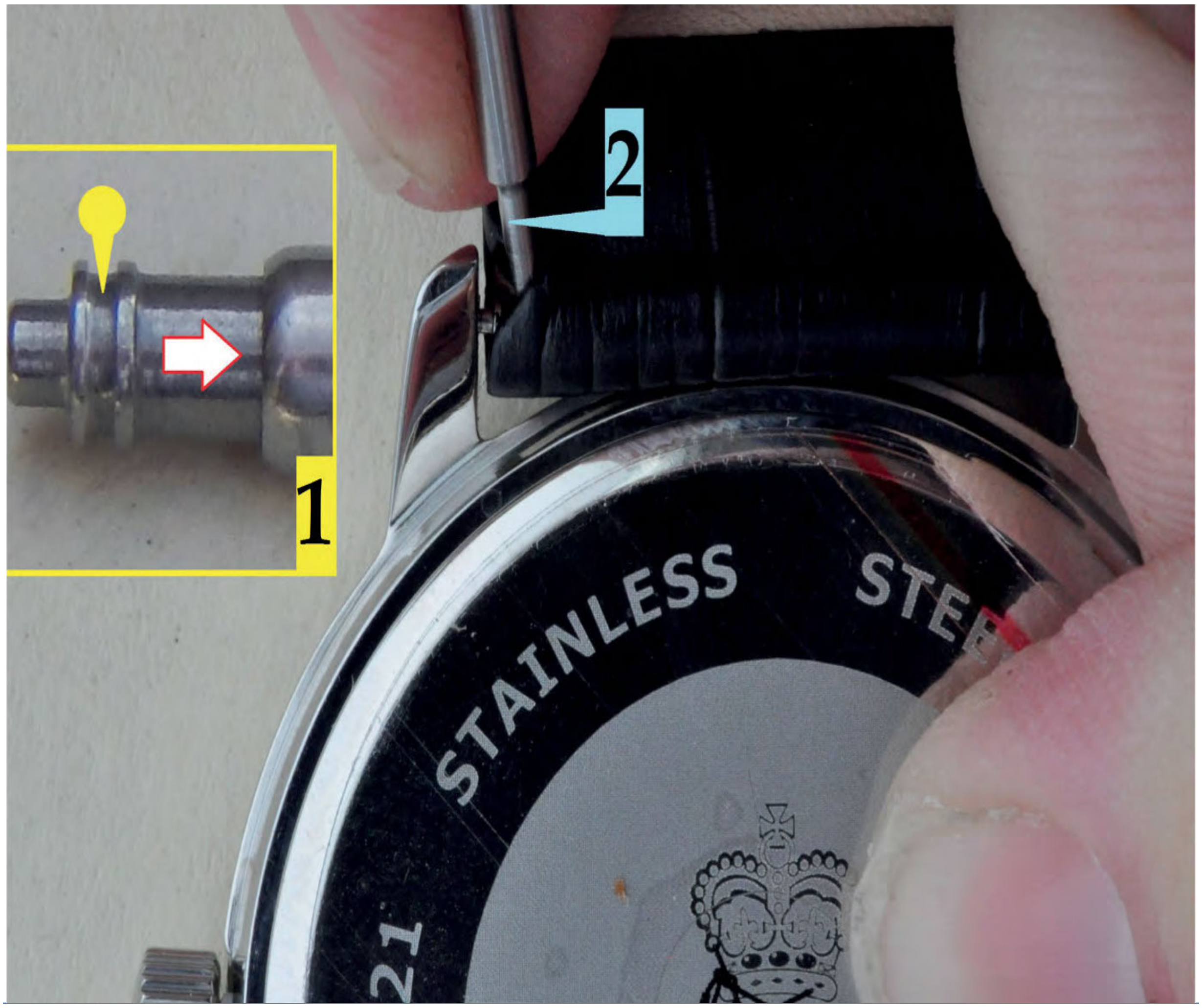


Fig. 46: Image 1: where to insert your strap tool into the middle of the lug flanges to remove the strap (shown by the yellow marker). Image 2: pulling back the strap to reveal the spring lug.

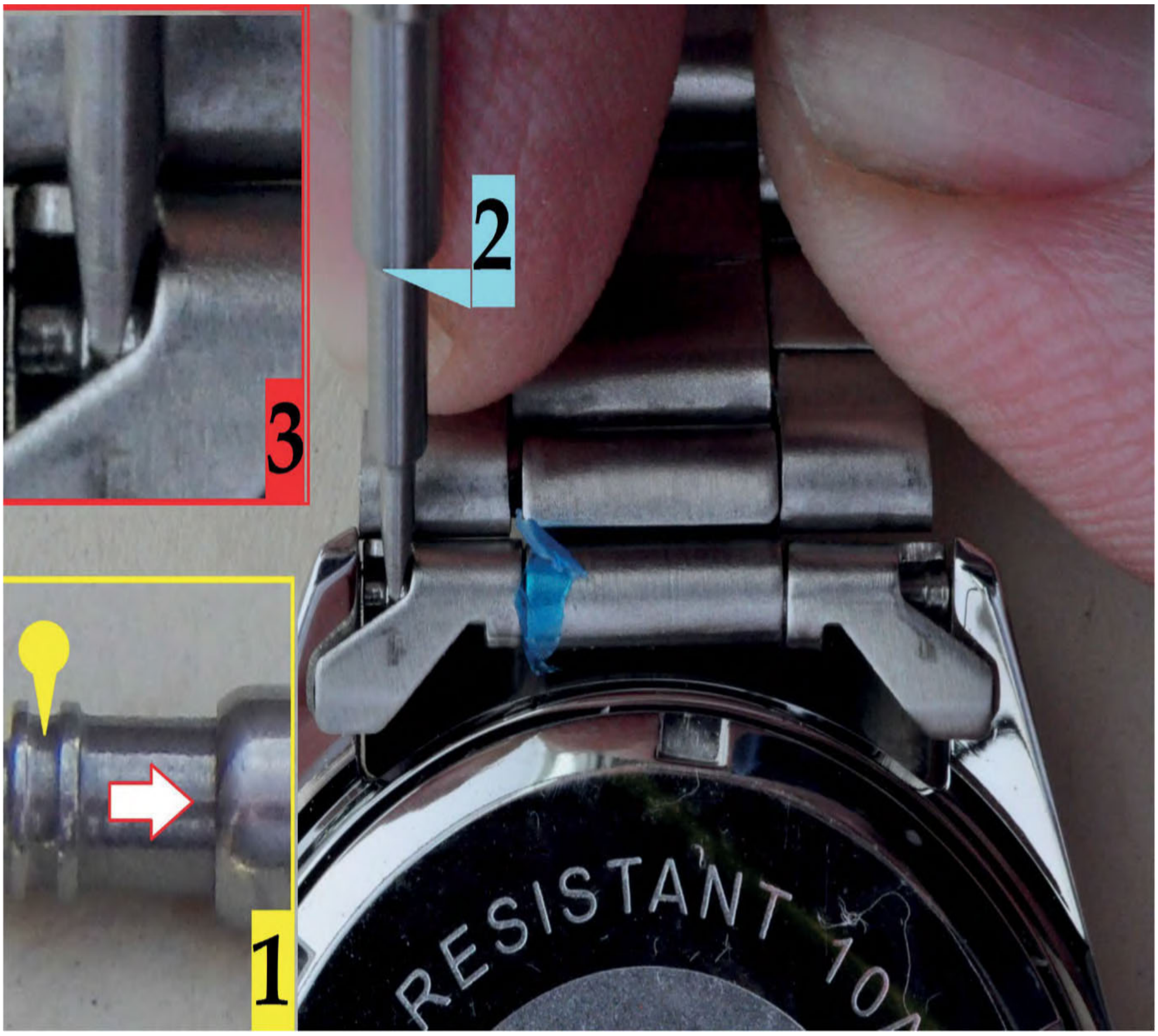


Fig. 47: Images 1 to 3: removing a metal bracelet. Image 3: the cut-out in the bracelet.

Tip: Before you remove any strap take note of which way round the strap or bracelet is fitted. It is the norm to find that the buckle end of the strap is fitted to the 12 o'clock end of the case, and a bracelet opens away from you at 6 o'clock. A watch with a leather strap that has a clasp-like bracelet – known as a deployment clasp – also opens at 6 o'clock.

To remove the strap of a blind hole case you will need to compress one end of the spring bar. To do this, pull back a small part of the strap, using the 'V' end of your strap tool to reveal the spring bar. This is the end of the strap where it meets the lug. Once you see the double flange, insert the 'V' of your tool in between the flanges and pull the spring lug so it retracts from the watch case, and at the same time pull the strap away from the case. If you are removing a bracelet, it's the same principle, except there is normally a cutout on the end piece of the bracelet opposite both lugs for the strap tool to be inserted, so you can pull back the spring lug for removal of the bracelet.

Tip: When you let go of the end of the lug with the tool, be careful not to let it fire across the room like a projectile, as you will never find it. They are very slippery, which is why it's best to keep a small stock of them for that day you're doing a friend or family member a favour! They can be bought from any jewellery supplier or watch spares dealer.

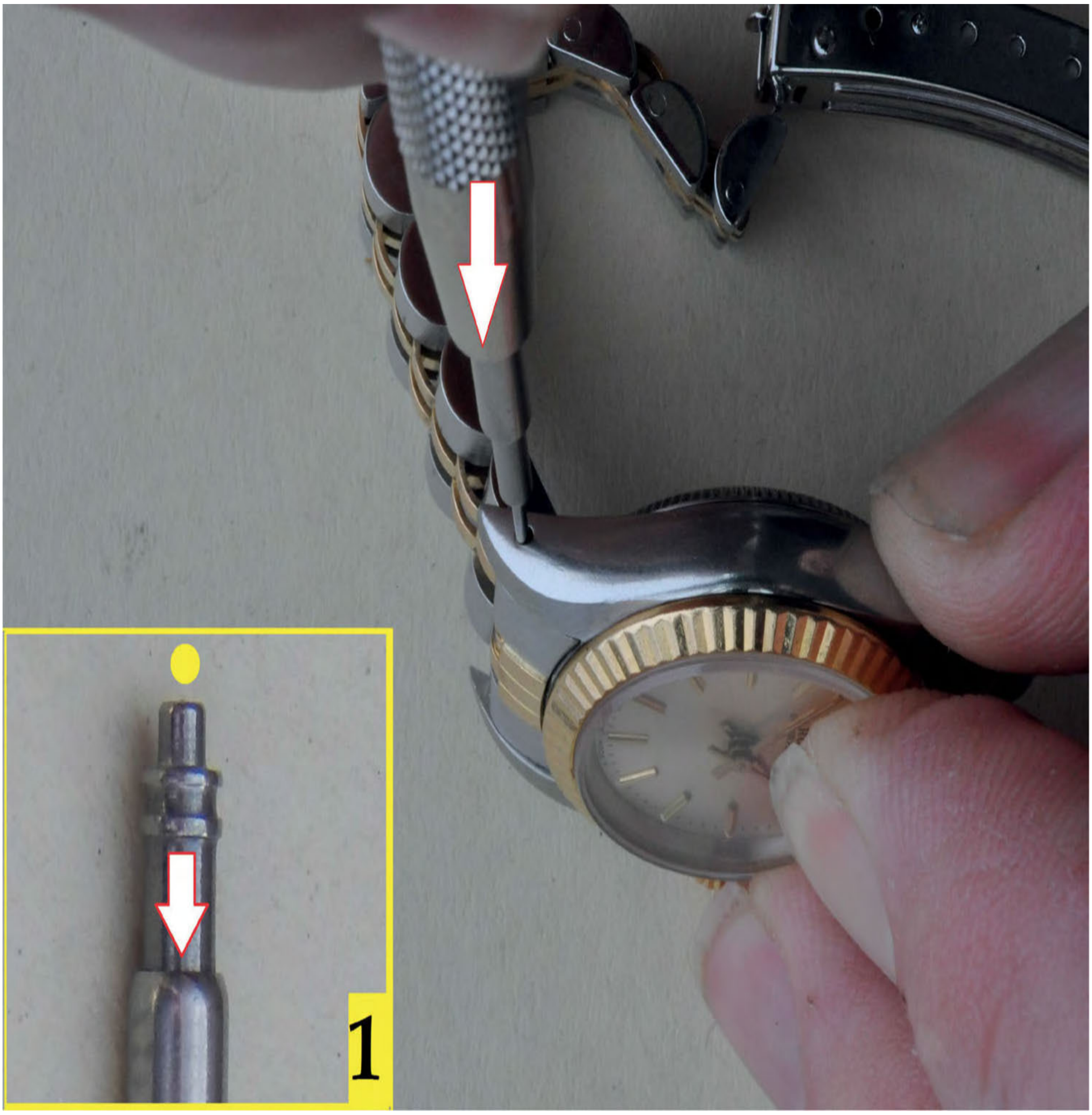


Fig. 48: A strap/bracelet being removed from a drilled lug using the round end of the strap tool.

REMOVING A STRAP FROM AN OPENED END CASE

This is the easier of the two, because to remove the strap you insert the round end of your strap tool into the watch’s lug and pull on the strap.

Tip: Once the strap is removed, this is a good time to clean the case, as the areas around the lugs are a hotbed for dirt (especially if you are thinking of replacing the strap). A stiff brush is best for this purpose – something similar to a toothbrush for stiffness would be ideal.

REFITTING THE STRAP/BRACELET

To refit a strap/bracelet to your watch, first the spring lug must be fitted in the strap or the end piece of the bracelet. Locate one end of the spring bar in one of the holes in a lug, then use the 'V' end of the spring tool, placing it between the two flanges, and compress the spring bar until it is inside the strap/bracelet. Straighten up the strap so that it is roughly where it is to be fitted. Using the strap tool, locate the spring lug's flange into the hole in the lug.

Tip: You can sometimes just depress the spring bar and line up the strap roughly where it is to be fitted and give it a little wriggle: if you're lucky it will click into place.

8. PICKING YOUR FIRST WATCH

The first watch that I recommend you work on is the Unitas, or ETA 6497 (or the Chinese equivalent, a Seagull ST25, which is of lower quality but cheaper in price). This model is a pocket watch, 37.24mm in diameter. If you can get this watch you will be able to follow the step-by-step instructions that I have laid out for you easily.

This type of movement is now more commonly found in large mechanical wristwatches. It was first made in the 1950s by Unitas as a pocket watch movement, and in its day was considered too big and bulky to be a wristwatch, unlike today where the wristwatch has become a fashion statement.

The only advantage of buying the Swiss movement over the Chinese equivalent is the availability of parts. So if you are naturally heavy-handed, you might be better off buying Swiss or purchasing a spare Chinese movement as a donor for parts. The Swiss version can be found in 1970s and 1980s pocket watches and can be picked up quite cheaply. A modern wristwatch case can be bought from various online sellers, to make yourself a contemporary wristwatch.

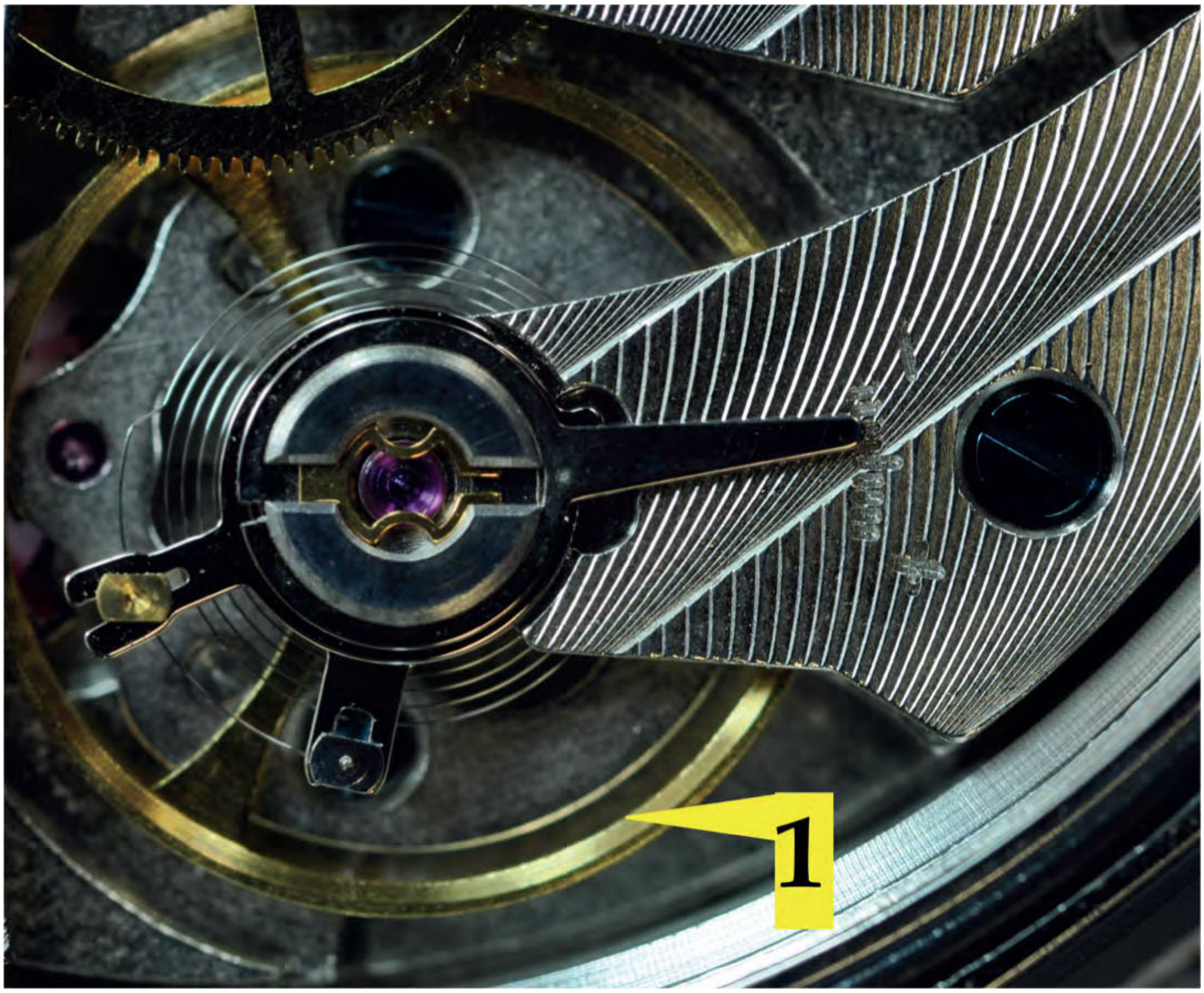


Fig. 49: The balance wheel and its spring. Image 1: Balance wheel.

IDENTIFICATION OF A WATCH MOVEMENT

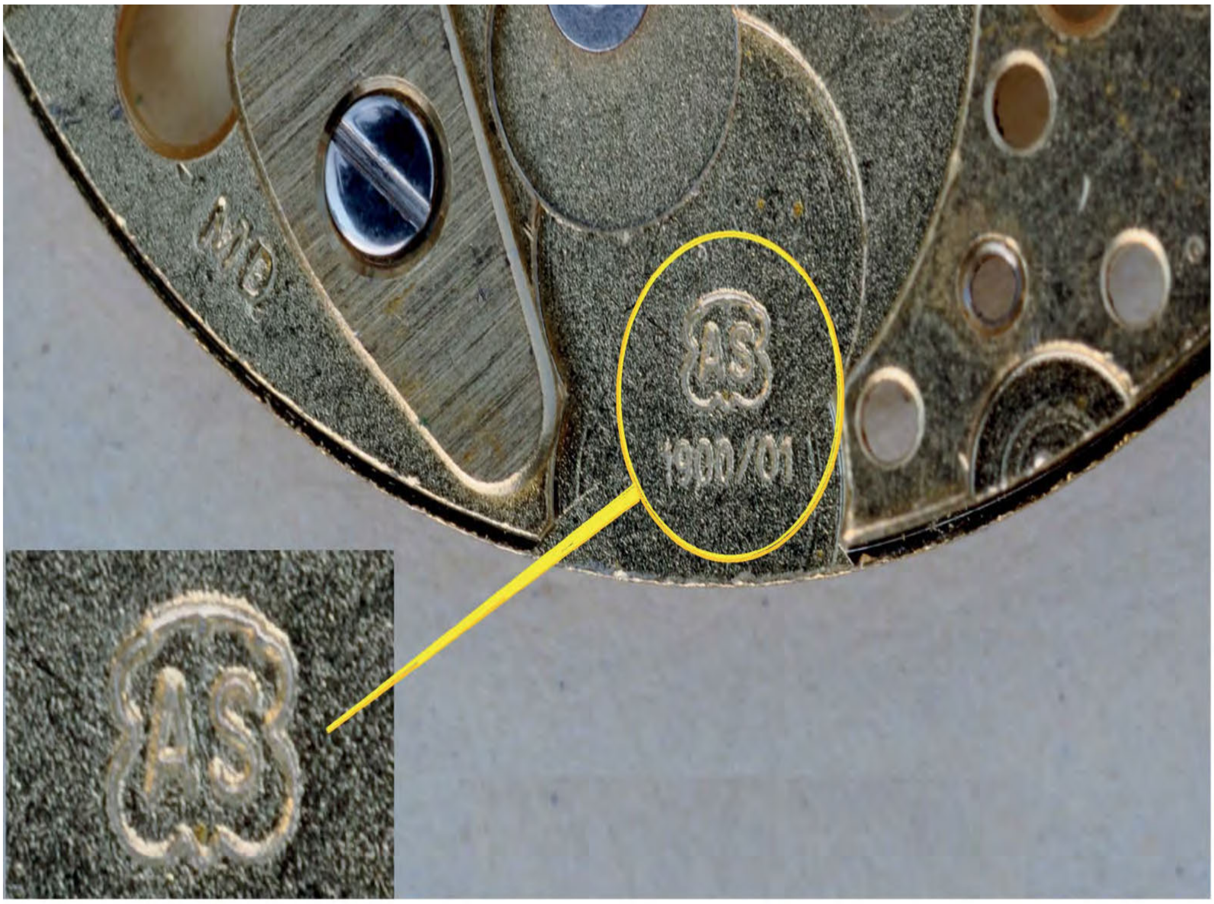


Fig. 50: The AS trademark and calibre number are found under the balance wheel.

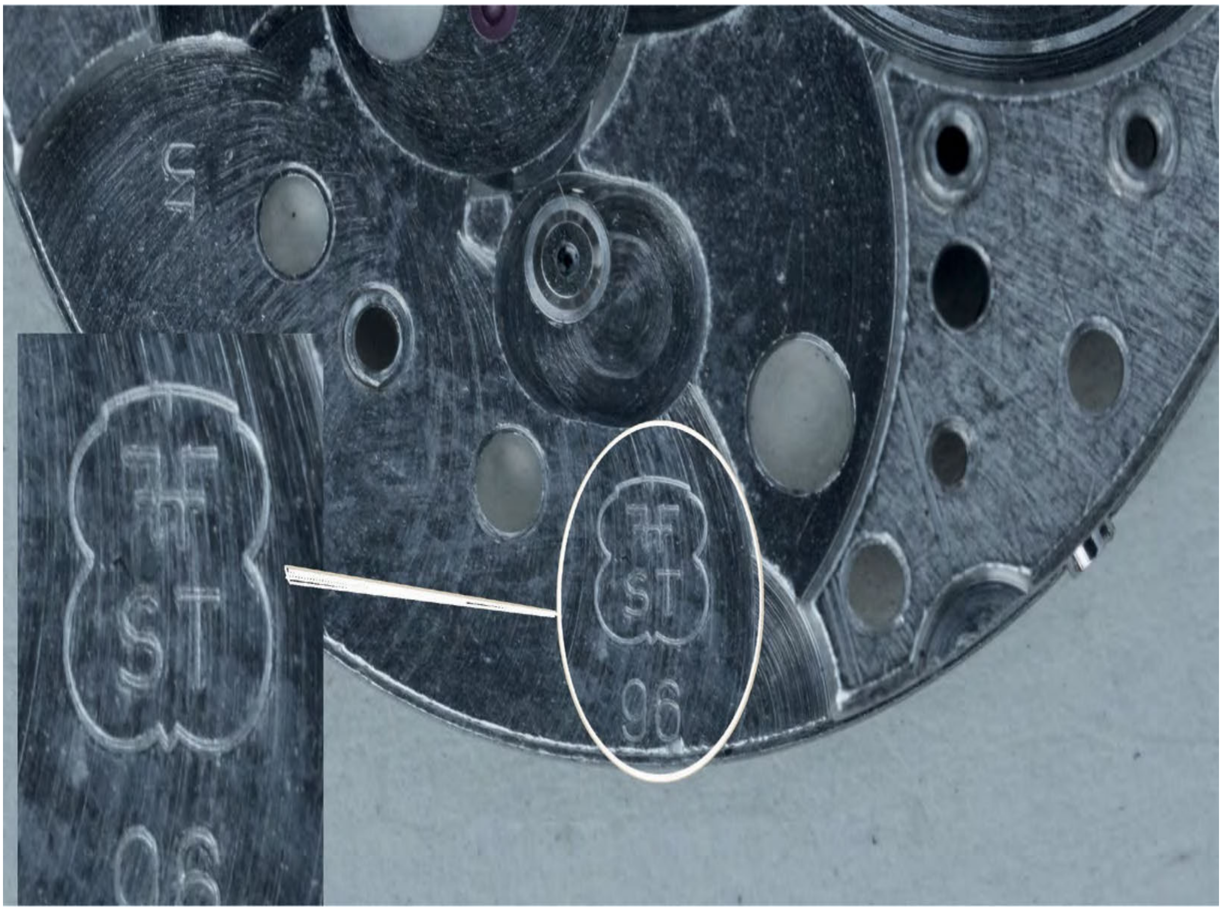


Fig. 51: The FHF and ST trademark and calibre.

Identifying a watch movement is important, because if you are to follow this book you will need to buy the right watch to work on, and there is a vast number of watch manufacturers out there. As long as there has been mass production there have been hundreds of watch manufacturers making watches under any particular brand.

You will be working on an ETA or Unitas movement to start with. ETA may not be a name you have heard of, and it might surprise you that they are the largest manufacturer of watch movements in Switzerland.

The following are the names you will most commonly find on movements: France Ébauches (EB), Valjoux (R), Derby (D), Peseux (P), FEF, Unitas (UT), Venus, Aurore Villeret (AV), Felsa (F), Landeron (L), Eterna (ETA), Fabriqués d'Horlogerie de Fontainemelon (FHF),and A Schild (AS).

You will notice that there is a letter or two shown after the name of each company; these letters are normally found near the balance wheel or under the dial. A letter or logo will be accompanied by some numbers which indicate the model: for example UT 6497 (Unitas 6497), or F 1560 (Felsa 1560). These help us identify a movement when we need to replace parts. The numbers can be split in two parts: the first part will indicate the size of the movement, and the second part what functions the watch has (that is, a date, or day date, or fast date change). If we look more closely at the watch you will be working on, there are two variations: 6498 and 6497 – the latter is only different in the fact that the seconds hand is in a different position and is indicated by the last number.

You may also see a decimal point and a number/letter after the calibre number, for example 6497.1 or 6497. A. This will indicate that the watch may have been uprated/upgraded from normal specification, or is an updated / revised model. Most watches made after 1960 have reference numbers and logos for easy identification. Anything older than this normally requires a little detective work using old reference books to identify them.

Lignes

The measuring system used by the watch trade is organized in 'lignes' (pronounced 'lines'), and has been adopted from the French inch, which is divided into twelve lignes. A ligne is 2.256mm (on the internet a ligne is given as 2.2558291mm: this is simply a more accurate conversion). The ligne is abbreviated to the letter 'L', or is represented by the triple prime, □.A ligne gauge will be found on most watch repairers' benches, and is normally about 10cm (4in) in length. Today, all modern manufacturers organize their identification catalogues by calibre number, but in days gone by they were sorted by their size in lignes.

A watch made before 1960 that had no numbers or logos would have to be identified through reference to books such as Ronda, Flume and Bestfit: these are the most commonly seen reference books for general identification. These books are no longer in print, but can be found on the internet or in specialist second-hand bookshops. The next step to identifying the watch would be to measure it with a ligne gauge. For example, if the watch measured 12½in, then you would simply look at the pictures in the 12½in section of the book, and match them to your movement to get a reference number for parts.

9. THE MOVEMENT

Once you have opened the back of the watch you will have exposed the mechanism: in the trade this is referred to as ‘the movement’. The mechanical watch movement is made up of many parts, and in this chapter I will cover the many different ways in which they are fixed and held together, as well as their relationship with each other.

The biggest part of any watch movement is the main plate: this is the platform of a watch, somewhat similar in principle to a car chassis, which forms the foundation for all other components to bolt on to. The main plate is normally round, or sometime oblong, and is typically made of brass, plated in a precious metal such as gold, silver or rhodium. This plating was originally used to stop the brass from tarnishing in the days before waterproof watches. Early watch cases were not able to keep out the air, damp or other contaminants, because when the metal movement and case expanded and contracted as the air temperature changed around them, it caused a bellows effect, a sucking action inside the case that pulled in the air outside, bringing in contamination with it.

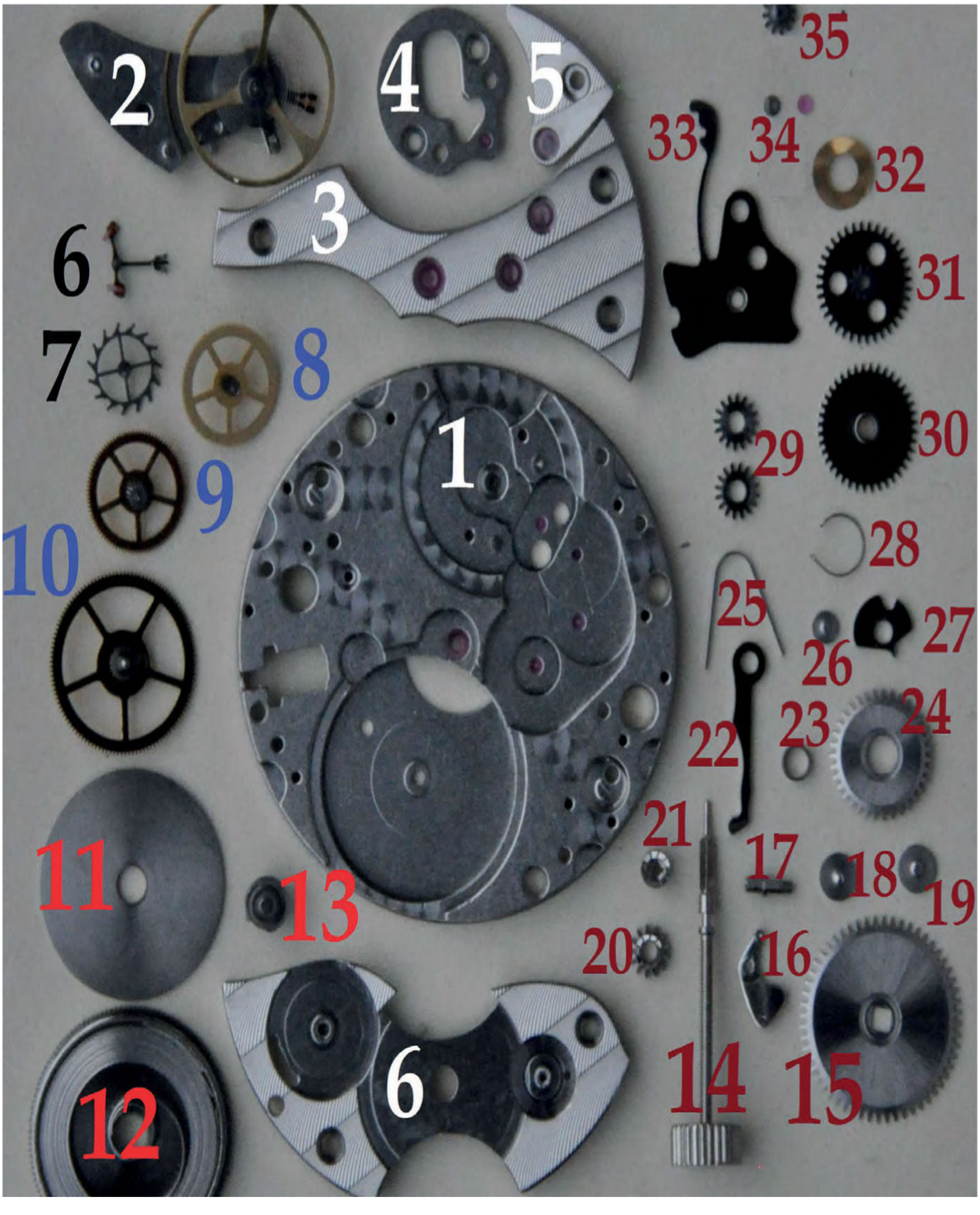

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Fig. 52: A basic watch in pieces: 1: main plate. 2: balance assembly. 3: train bridge. 4: pallet bridge. 5: escape-wheel cock. 6: pallets. 7: escape wheel. 8: fourth wheel. 9: third wheel. 10: centre wheel. 11: barrel cap. 12: barrel with spring. 13: barrel arbor. 14: stem and crown. 15: ratchet wheel. 16: bolt piece. 17: bolt screw. 18: ratchet-wheel screw. 19: upper crown-wheel screw. 20: winding pinion. 21: sliding clutch. 22: return bar. 23: upper crown-wheel washer. 24: upper crown wheel. 25: return-bar spring. 26: click-retaining screw. 27: click. 28: click spring. 29: intermediate setting wheels. 30: hour wheel. 31: minute wheel. 32: hour-wheel washer. 33: cover plate with bolt spring. 34: end stone and chaton. 35: cannon pinion.

In those days, plating watch components in a precious metal was one way to prevent the brass components deteriorating. Those who have a brass door knocker or letterbox and polish it regularly, know how quickly it tarnishes, so by coating it in gold or rhodium you are protecting the base metal with a substance that will not tarnish.

In this modern age of water-resistant watch cases, plating the brass components is not really necessary, other than to show off the quality and skill of the craftsman or manufacturer who made the watch: it is purely decoration. It is the norm to find that all the brass components are plated, and any steel components are normally polished to a mirror finish, or sometimes heat treated to a dark blue in colour.

Blueing the steel also helps prevent tarnishing of the steel that the screws are made from, and also makes them look pretty.

All the gears and levers and other moving parts are held between the main plate and their corresponding bridges (reference numbers 3, 4, 5, 6 in Fig. 48) or cock (no. 2).

Bridges and cocks are basically the scaffolding that holds any moving parts in place above the main plate.

Cocks have a single post with a canopy that overhangs it. A ‘bridge’ has a canopy supported by two posts, one at each end for extra support (as the name suggests, it resembles a basic bridge).These canopies normally have a round red jewel set into them, a synthetic ruby: in antiquity these were real rubies/garnets and diamonds, which is why they are still call ‘jewels’.

In the centre of the jewel is a drilled hole which is highly polished: the jewel is a bearing in which a gear’s axle will rotate, and the highly polished surface and actual nature of the jewel help to reduce friction (less friction means that less power is needed to drive a watch, and this means the watch can be made smaller and lighter).

There will be a matching jewel in the main plate which is directly below the jewel in the cock or bridge. Between these aligned jewelled bearings will be a gear with an axle that is called an arbor. At each end of this arbor will be waisted extensions, called pivots. The two pivots are very slightly smaller than the diameter of the hole in the jewels, about .01mm in diameter. The arbors will also be very slightly shorter than the inside distance between the base plate and the cock/bridge – about 0.10 to 0.40mm, about the thickness of a piece of paper. This allows clearance so that the arbors and pivots can rotate freely.

If we look more closely at a cock or bridge, particularly the underside of the post, we should notice one or two protrusions at its base. These are small short pins that are very slightly tapered, called steady pins. Their job is to mate with a matching set of holes in the main plate, into which they will snugly locate. These pins hold the bridge or cock steady and in place.

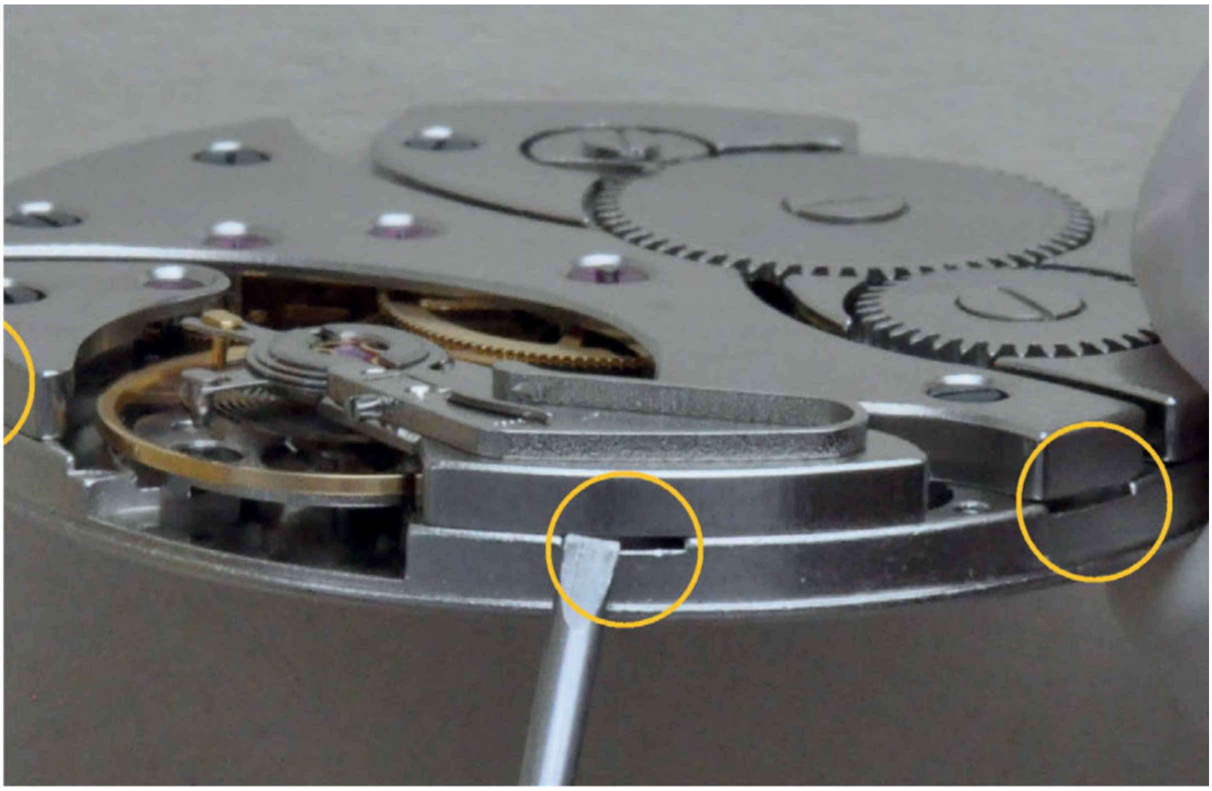


Fig. 53: The cut-outs into which a screwdriver can be inserted to lift up an unscrewed bridge or cock from the base/main plate.

The final fixing is a screw or two, to make sure that the part does not move; when removed for maintenance, it will refit exactly as it did before. If the bridge or cock were to move, it would affect the relationship of the working effectiveness of the gears that they are keeping in place.

Bridges and cocks come in all shapes and sizes. They are made out of the same material as the base plate, with the same finish. They also normally have a notch cut out of the base, as seen in Fig. 49. This is to help the repairer remove the bridge/cock, using a screwdriver as a lever. This also helps to prevent damage to the cock/bridge as it is being removed.

MANUAL WATCH MOVEMENT LAYOUT

There are three types of manual watch movement layout: full plate, three-quarter plate and bar movements.

Full Plate

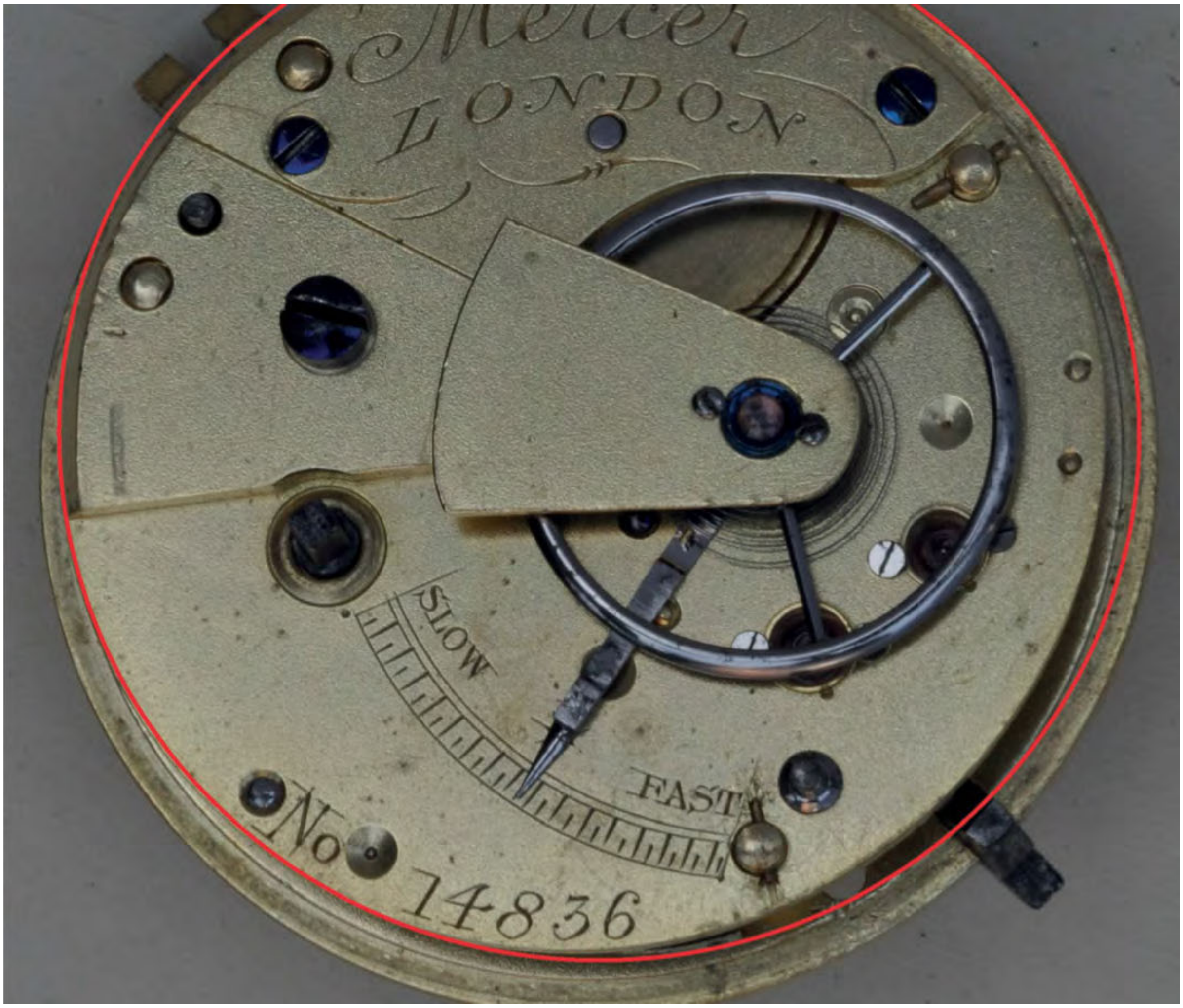
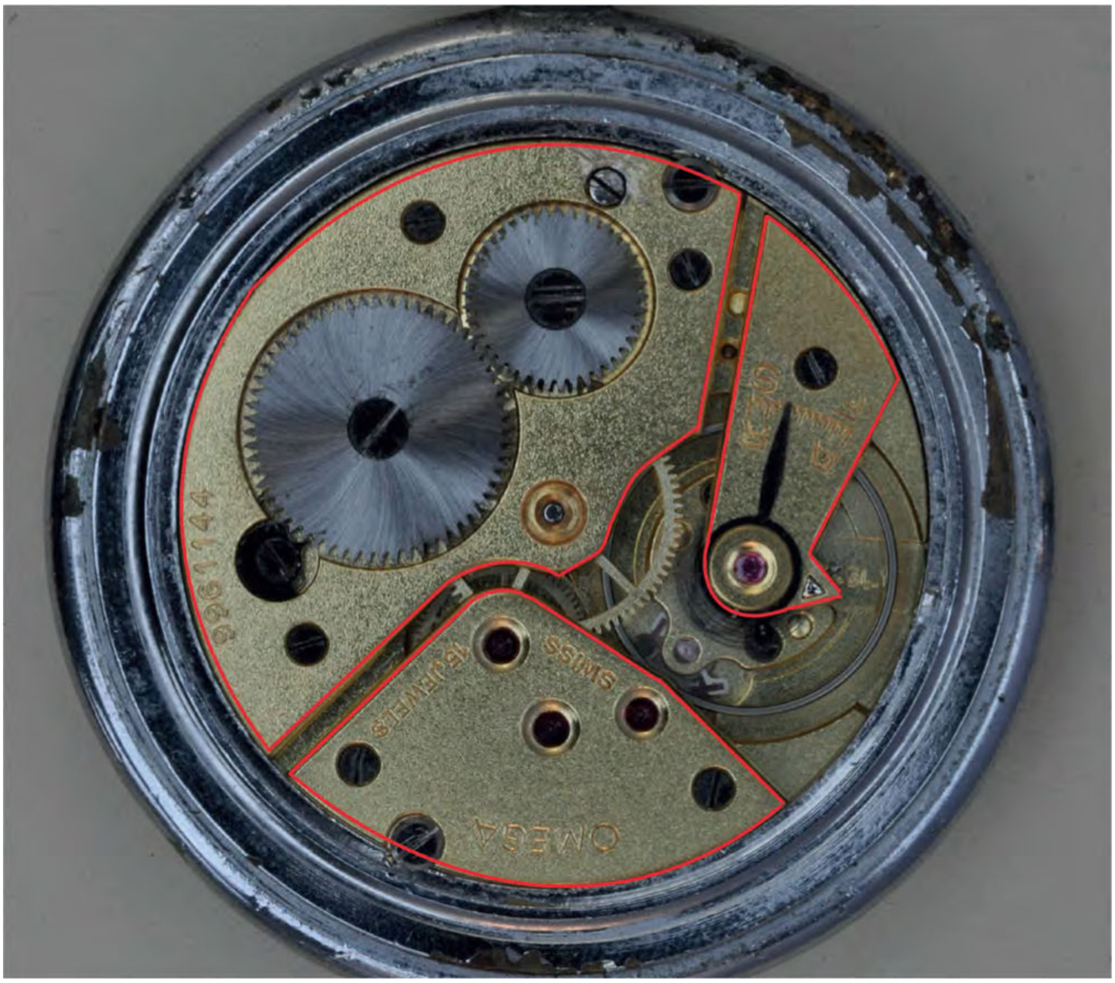


Fig. 54: Pocket watch by Mercer of London: a full plate movement.

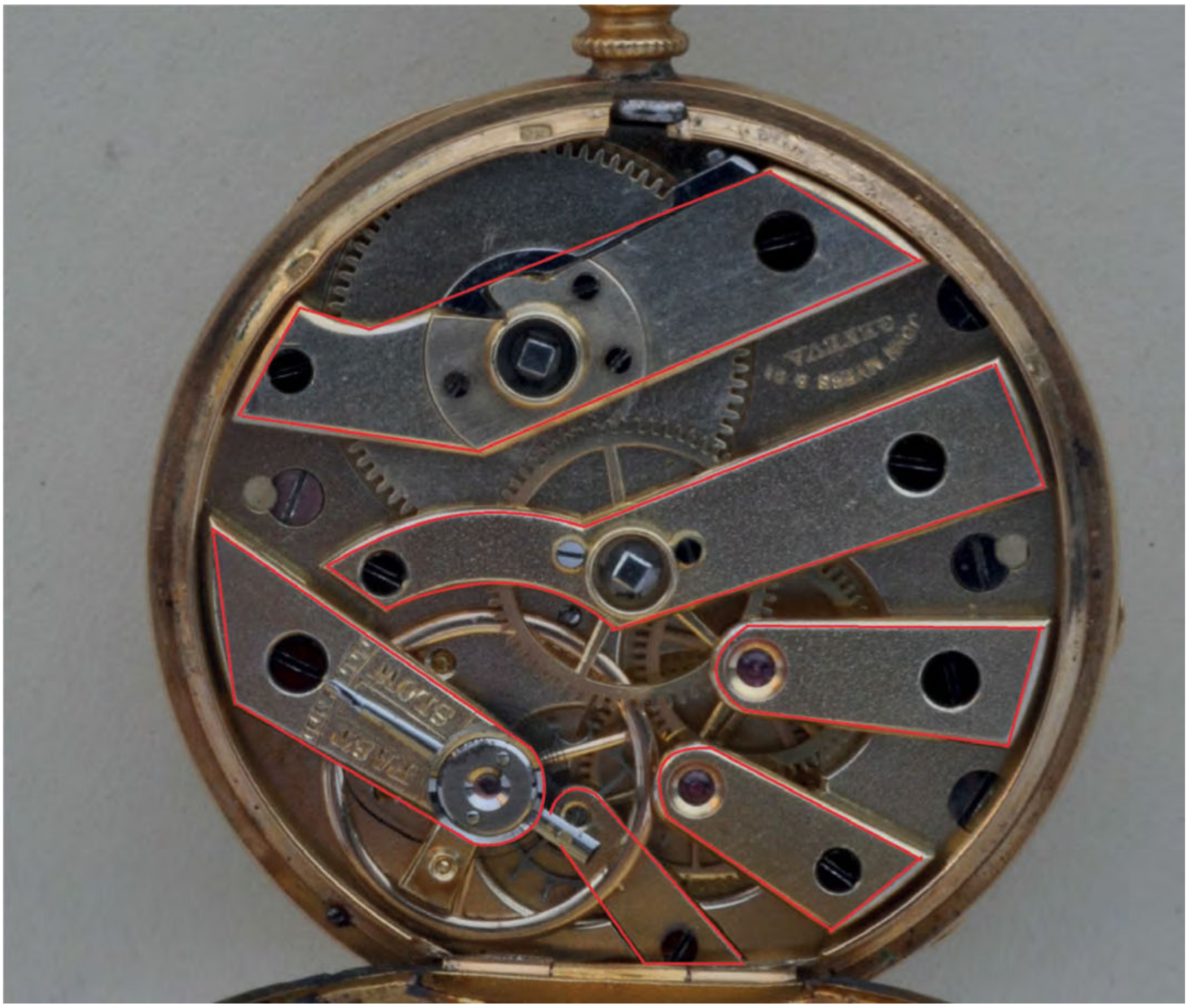
A full plate movement is generally found in antique watches, and normally has only one bridge or cock supporting the balance wheel. The general construction of early watches tends to take after clocks, in that they have a base plate and a top plate supported by pillars, each of which has a shoulder on which the top plate rests. A smaller extension of the pillar passes through a mating hole in the top plate, and extends right though the plate. Just as the pillar leaves the plate on its side there is a hole passing through it. This hole is used to secure the two parts together with a tapered pin made of brass pressed into its hole. This is probably one of the harder watches to work with as most of the gears in the movement are covered and can only be viewed from the side.



Three-Quarter Plate

Fig. 55: Military Omega pocket watch with a three-quarter plate movement.

A three-quarter plate movement is probably the most common movement layout in the world of watchmaking, and is the movement of the first watch you will be working on. It is called a three-quarter plate because what would be the top plate has been divided into three parts: one part is occupied by the balance and its cock; the next is filled by the gear train and its cock – this can be thought of as the watch's gearbox, if you like; and the final third is home to the main spring and its bridge. All the cocks and bridges are secured to the main plate with screws or steady pins.

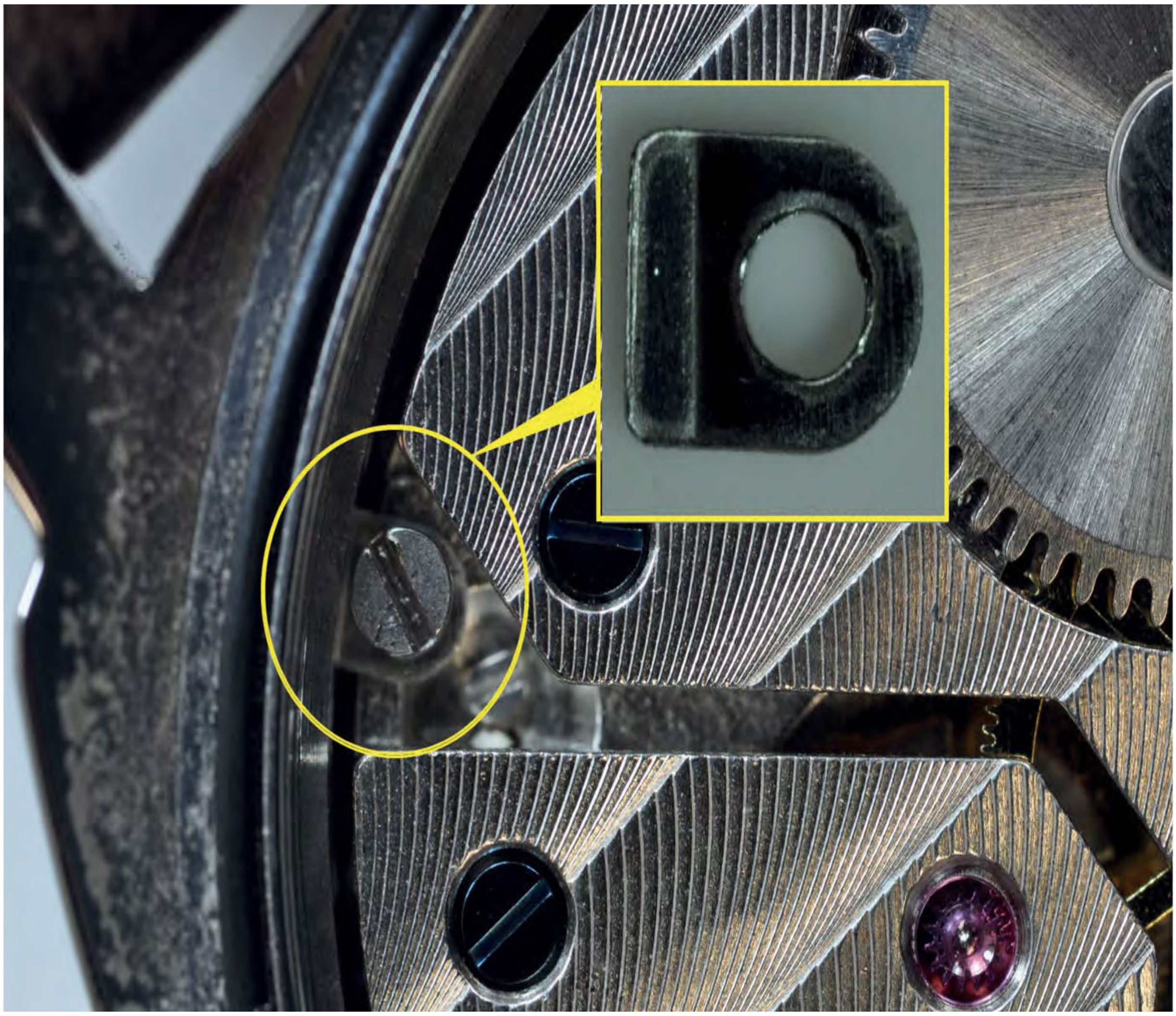


Bar Movements

Fig. 56: An Edwardian pocket watch with a bar movement.

A bar movement has a bridge or cock for every wheel, including a separate bridge for the barrel and centre. This type of movement has gone out of fashion, probably due to the cost of separate bridges and the extra screws needed to hold them in place. This was a common type of layout and was very popular with manufacturers of the late 1800s, but disappeared in the 1920s. This type of layout makes the movement very easy to work on, as you have clear access to each individual part.

PART II: HOW A WATCH WORKS



10. REMOVING THE MOVEMENT FROM ITS CASE

Fig. 57: A case clamp.

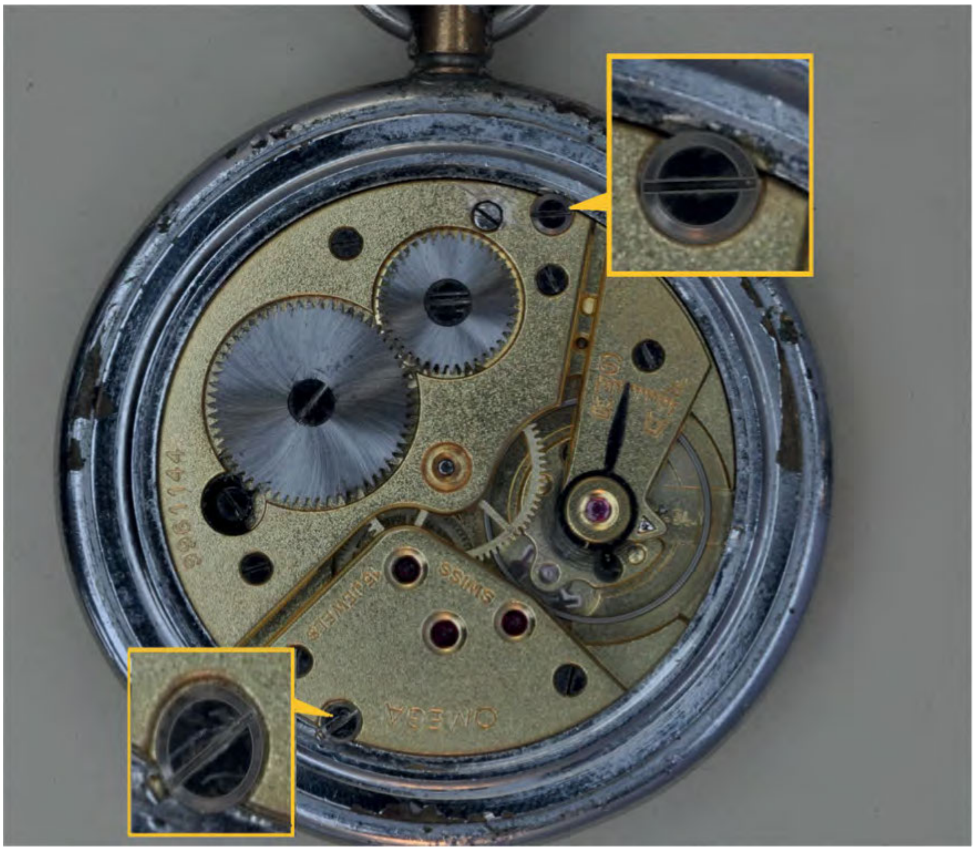


Fig. 58: Case screw.

The watch in Fig. 57 has two clamps with securing screws holding the movement firmly in the case. This is so that during hand setting or winding the watch movement doesn't move in the case and, more importantly, so the watch movement doesn't rattle or flap about in the case when the watch is being worn. Case clamps are small pieces of metal that resemble the door pull on a Yale door lock. Alternatively you may find you have a movement that is secured in the case by just screws without case clamps, as in Fig. 58. These are quite long screws, normally the thickness of the movement.

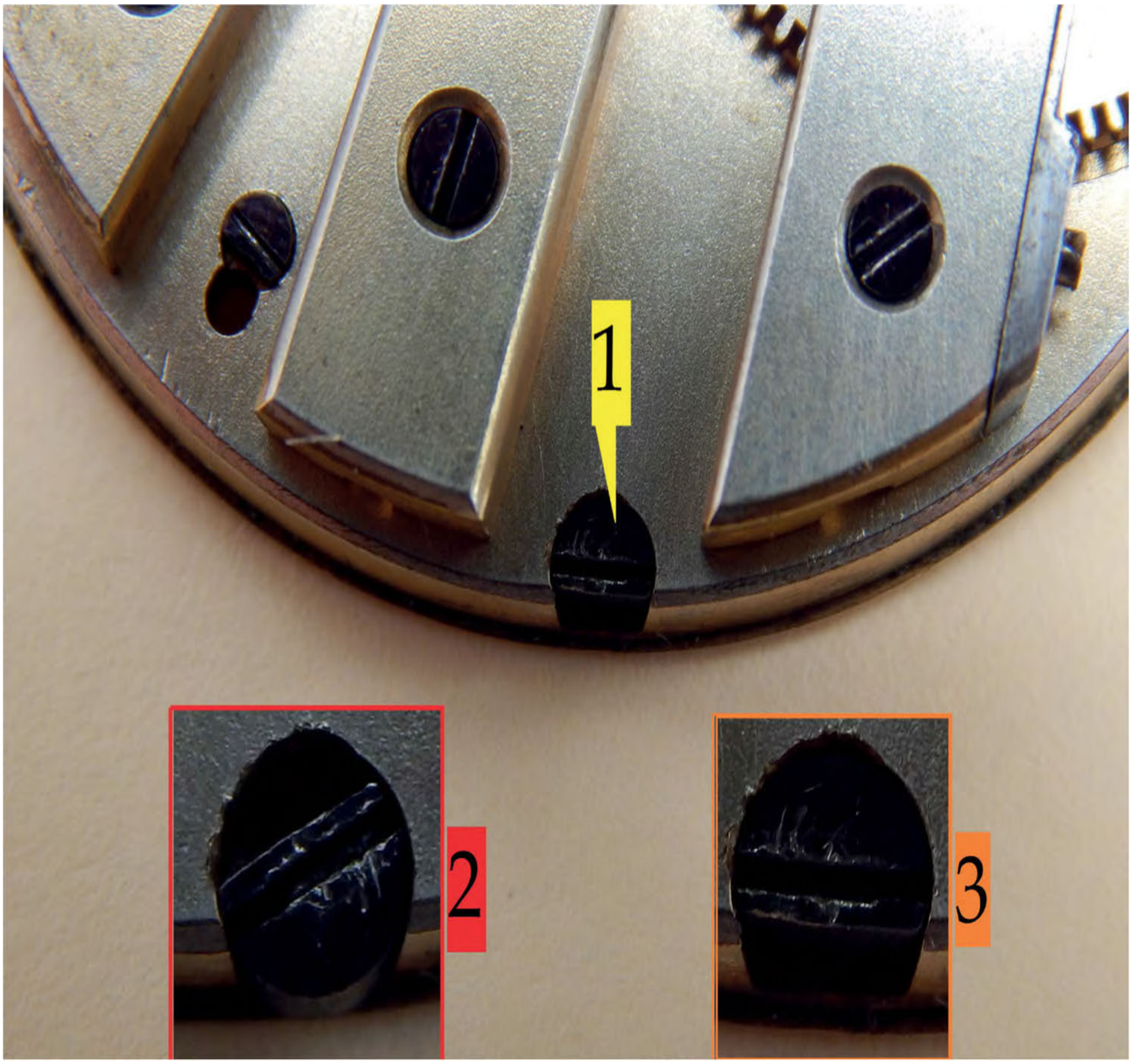


Fig. 59: Image 1: a half-cut case screw, shown in two positions – locked (image 2) and unlocked (image 3).

If you are working with a much older style watch, you may find that you have only one case screw that looks like the one in Fig. 59.This case screw has had half of its head removed, meaning that the screw will have to be rotated no less than half a turn to remove the movement from the case.

On a more modern watch you may find that you have a spacer ring around the movement, called a movement ring. This developed due to watch manufacturers using a stock movement that was smaller than the hole in the case it was meant to fit, rather than one that was made to fit each case. It is not uncommon to find the movement ring made out of plastic, especially in fashion watches, but more commonly they are made of brass and plated to match the movement.

Some cheaper watches have a movement ring that is not secured to the case by clamps or screws, and which relies on the watch’s case back clamping down on it to hold it in place. This type of ring is made to compress, as small sections are cut out on the very top of the rim to form a compression spring.

So why do watches have movement rings at all? Why not just make a watch the right size? Well, manufacturers will typically have three or four types of watch movement in their range, and the addition of a spacer or movement ring means that a movement can fit hundreds of different case styles. This is not dissimilar to car manufacturers and their engines.

REMOVING THE CASE CLAMP SCREWS

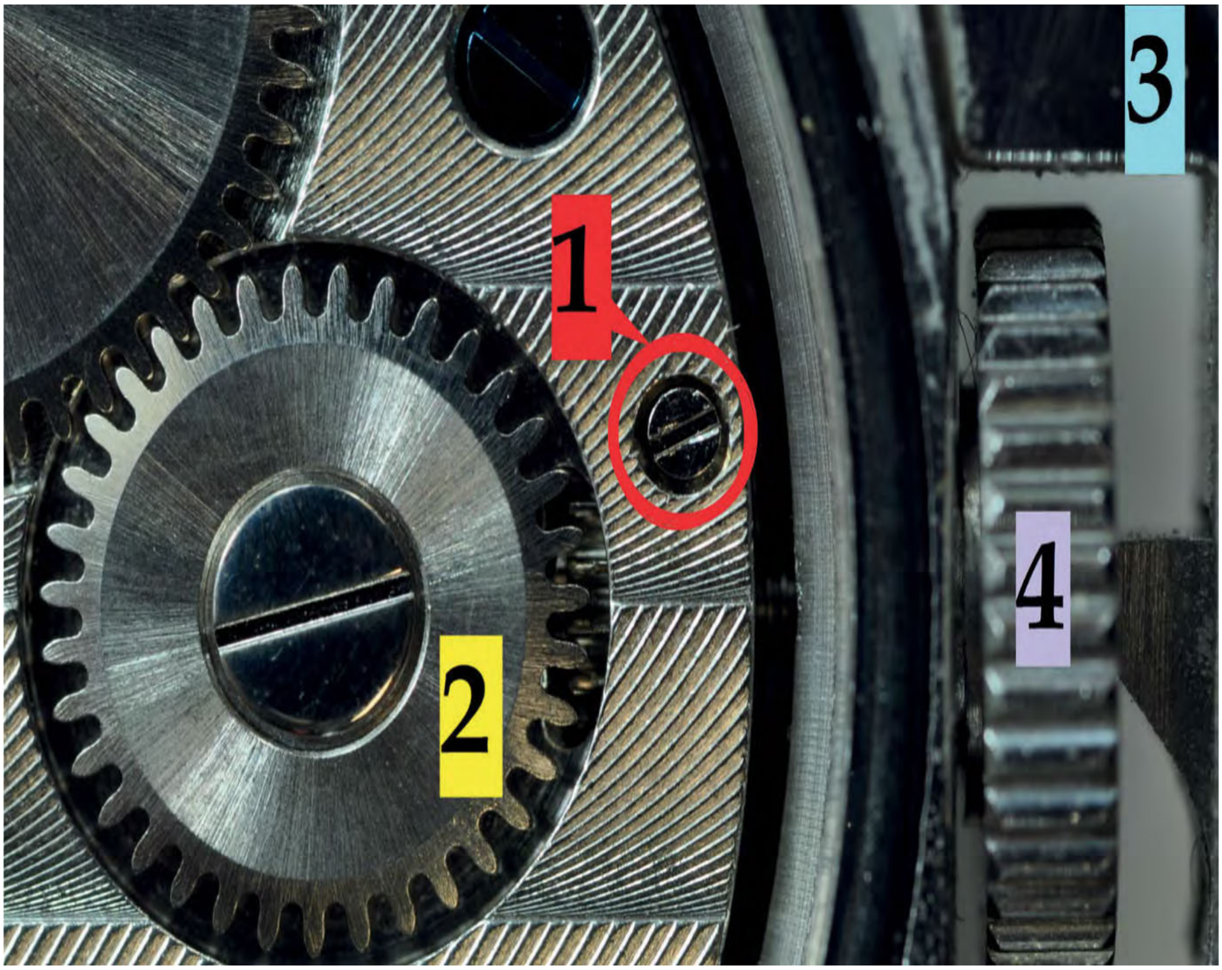


Fig. 60: Image 1: bolt screw. Image 2: upper crown wheel. Image 3: crown guard. Image 4: winding button or crown.

To remove the case clamp screws set the hands of the watch to 12 o'clock, using the winder (this will make things easier later on when you have to remove the hands). Using a screwdriver with a blade that is nearly the same width as the screw, remove both the case clamp screws (they are normally found opposite each other. In more modern watches there will be three sets of screws and clamps evenly spaced around the movement).To undo a screw in a watch, turn it with your screwdriver until you hear a little click noise: this is the sound of the end of the thread coming out of its hole. The screw is now free to lift out with your tweezers, and the case clamps should just pull out by grabbing them with your tweezers.

Once both clamps have been removed the movement will be loose in the case, and the only thing stopping you from removing it will be the stem and button.

Removing the Winding Stem and Button

Now that you have removed the case clamps, the next task is to remove the winding stem and button. To do this, you must loosen the bolt screw. If you look round the outer edge of the movement, identify where the stem enters the movement, and about two degrees left or right of the stem, there will be a screw that is smaller than the rest. Using a screwdriver that is nearly as wide as the screw, rotate it, but only one and a half turns.

Warning! You are not removing this screw: it holds in place a small lever called the bolt piece, which holds the winding stem and button in place.

Once loosened, proceed to pull on the winding button. The winding stem should now just pull out from the watch, unless you have a watch with a crown/button guard (a bridge of metal that covers the crown/button). If so, there will be two screws that are holding it in place, and they will have to be removed. If the winding stem is unwilling to detach from the movement then a quarter of a turn extra on the bolt screw may be needed.

Once the winding stem is free from the case, place a piece of paper or a plastic bag over the top of the movement. Carefully flip both over on to the bench, so that the dial is facing you. The watch movement should just drop out of the case and will now be lying on your work top. As you lift the watch case up, the movement should be displayed in front of you with both the dial and hands exposed.

Warning! If you wish to stop at any time and want to store the watch movement, I suggest you do so by putting it safely in an airtight pot, keeping it with the dial facing upwards to prevent it from becoming marked. I would also suggest that when removing the dial you keep it separate from any of the metallic parts of the watch. The paint on a watch dial is very soft and is easily marked or scratched, and this will minimize any risk of damage.

11. REMOVING THE HANDS

TOOLS NEEDED

The tools that you will need to remove the hands of the watch are hand removers – a Bergeon presto tool or hand levers – and a dial protector. For the latter a Bergeon dial protector or similar is best; alternatively a piece of paper about 3sq cm with a V section removed from the middle can be used. You can make this with a Stanley knife or watchmaker's case knife.

If you have a watch that has a crown (button) which is larger than the thickness of the movement, you will need to remove the winding stem and button before removing the hands. If you were to continue to press down on a movement with a large crown, there is a high chance that you would snap the winding stem in half. Alternatively you could set the hands to 12 o'clock before you remove the movement. To do this, refit the winding stem in the movement and tighten the bolt screw with a screwdriver. Once fitted, pull the stem so that the watch is in hand set (the position you would use to change the time), and set the hands to 12 o'clock.

Tip: When refitting the stem it is always wise to rotate the stem anticlockwise slowly as you insert it. Once fitted, proceed to tighten the bolt screw. This rotation of the stem will help the gears inside locate.

With the movement on your bench mat, on its back with the dial and hands facing you, proceed to slide the homemade or Bergeon dial protector between the hour hand and the dial.

FINGER COTS

As you are handling the movement at this point I would recommend using finger cots on your left hand (assuming you are right-handed). A professional watch repairer would normally use three, but I would recommend that you use four, leaving your little finger uncovered. Because you are a beginner you may well be unaware of what your ring finger is doing, and there will certainly be times when you touch things with it without realizing.

You may be thinking, why is this a problem? Well, our body consists of vast quantities of water, and this moisture, when excreted from the pores in our fingers, is actually acidic.

Watches are largely made from quantities of brass and steel, and these metals can be very easily damaged by these acids. So if a sweaty-fingered watch repairer handles a watch movement with unprotected fingers, this acidic moisture will cause rust or pitting in the steel and brass. I have even seen the outline of a previous repairer's fingerprint permanently etched into the movement.

Whether you are hobbyist or professional, just as doctors have a hippocratic oath to do no harm, you must also try to adopt this mantra, because one day the watch you are working on will be an antique or may be valuable, and without due care you will certainly damage it, and the shame this may cause will last beyond your lifetime – people are very quick to point the finger at the last person to work on the watch! Remember that a mechanical watch is made to last several generations, and any damage caused to it will also last as long.

Tip: Take care when buying finger cots. I have quite slender fingers and use the large size, so those with beefier fingers might need the extra-large size. The catering trade and the medical professions also use finger cots, so shop around and don't settle for the branded ones, as they can be obtained much more cheaply (at the time of writing try Medisupplies or Cousins). If you find that they threaten to cut off the blood supply in your fingers, then try cutting off the end of the cot – the rib part – to relieve the pressure. Next time you might want to buy the bigger size.

If you don't like finger cots, you could use acid-free tissue paper, sometimes called 'watch papers', as a barrier between your fingers and the part being held. This product can also be found in art shops and book-binder supplies; as a last resort you could use greaseproof baking paper – it's not quite the same, but it's better than nothing.

USING THE BERGEON PRESTO TOOL

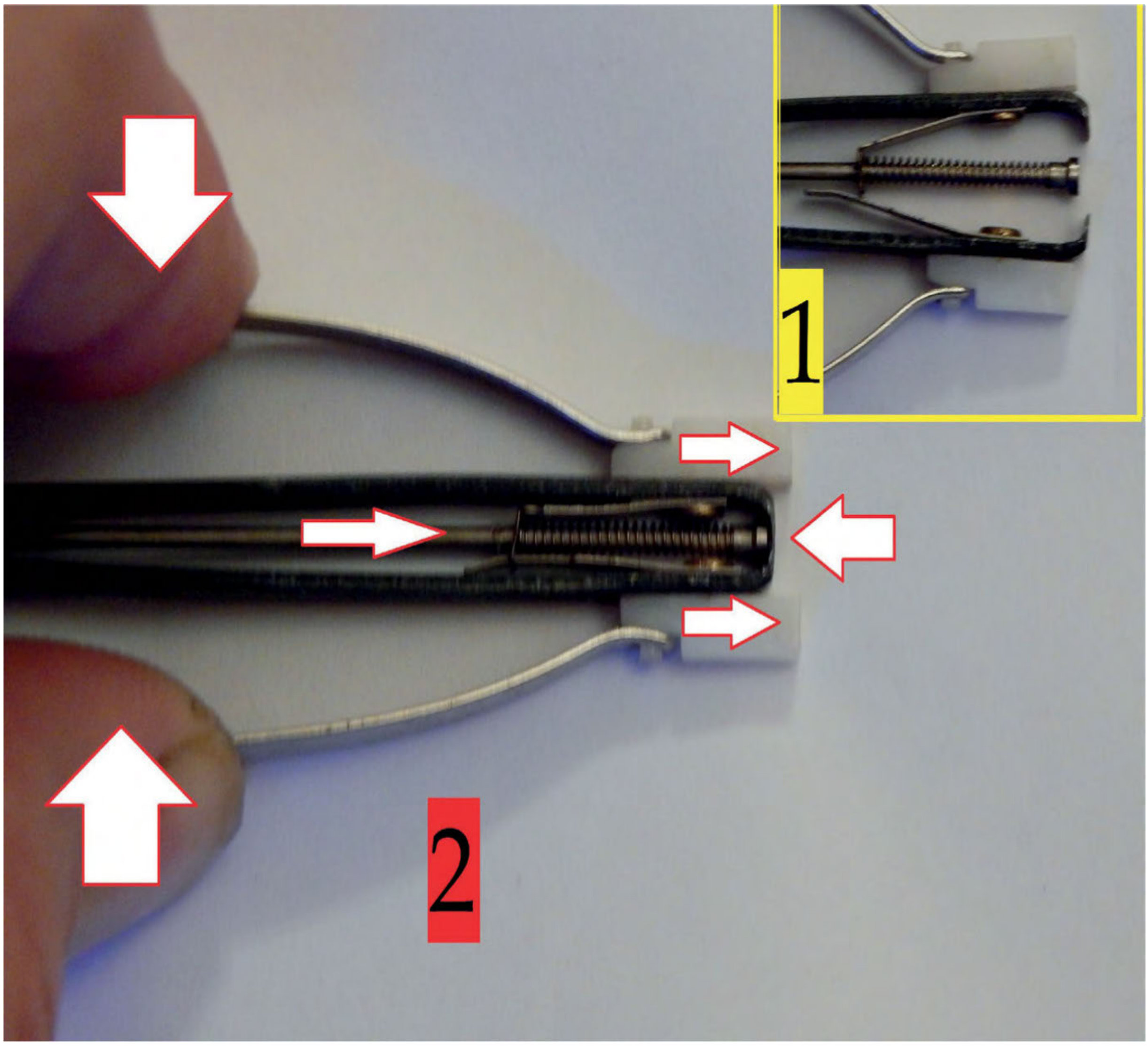


Fig. 61: Bergeon presto hand remover tool. Image 1: the tool in its rested state. Image 2: what happens when the tool is squeezed.

Before using this tool I suggest having a play with it to understand how it works. If you use it without prior knowledge and due care, you will certainly damage the hands, if not the dial, of the watch you are working with. With this tool the action takes place very quickly, and there is nothing you can do to stop it if you see things going wrong! This tool is great for beginners, but if you can use your hands with equal dexterity at the same time, I would recommend swapping it for hand levers. I prefer levers, as I can see and control the speed and angle of the removal, plus I can also feel what's happening at the same time.

To use the Bergeon presto tool, first slide the dial protector under the hour hand to protect the dial from the tool. Next, carefully slide the jaws under the hour hand, taking care not to mark the soft paint of the dial round the base of the hands. You should also try not to scratch the top surface of the hour hand (known as the boss). Make sure you keep the tool as vertical as you can, then squeeze the two springs on the side of the tool.

The centre plunger will press on the centre of the minute hand – if the watch has a centre seconds hand the plunger will press on this instead – and the white plastic feet will push down on the dial protector. As this happens, the jaws will close round the boss of the hour hand, which will rise up, levering the hands away from the movement – and 'presto!', the hands are removed. If you keep a light squeeze on the tool, the hand will be kept in the tool by the plunger. Put the hands in a safe place in your storage box by releasing some of the tension on the two springs.

Do not use this tool without a dial protector as you will certainly damage the dial when the plastic feet push against it.

Warning: My advice with any dials is this: if in doubt, leave well alone. However, if you are feeling particularly brave, and are not worried about the state of the dial, then follow the advice given in the 'Coloured Dials' section below.

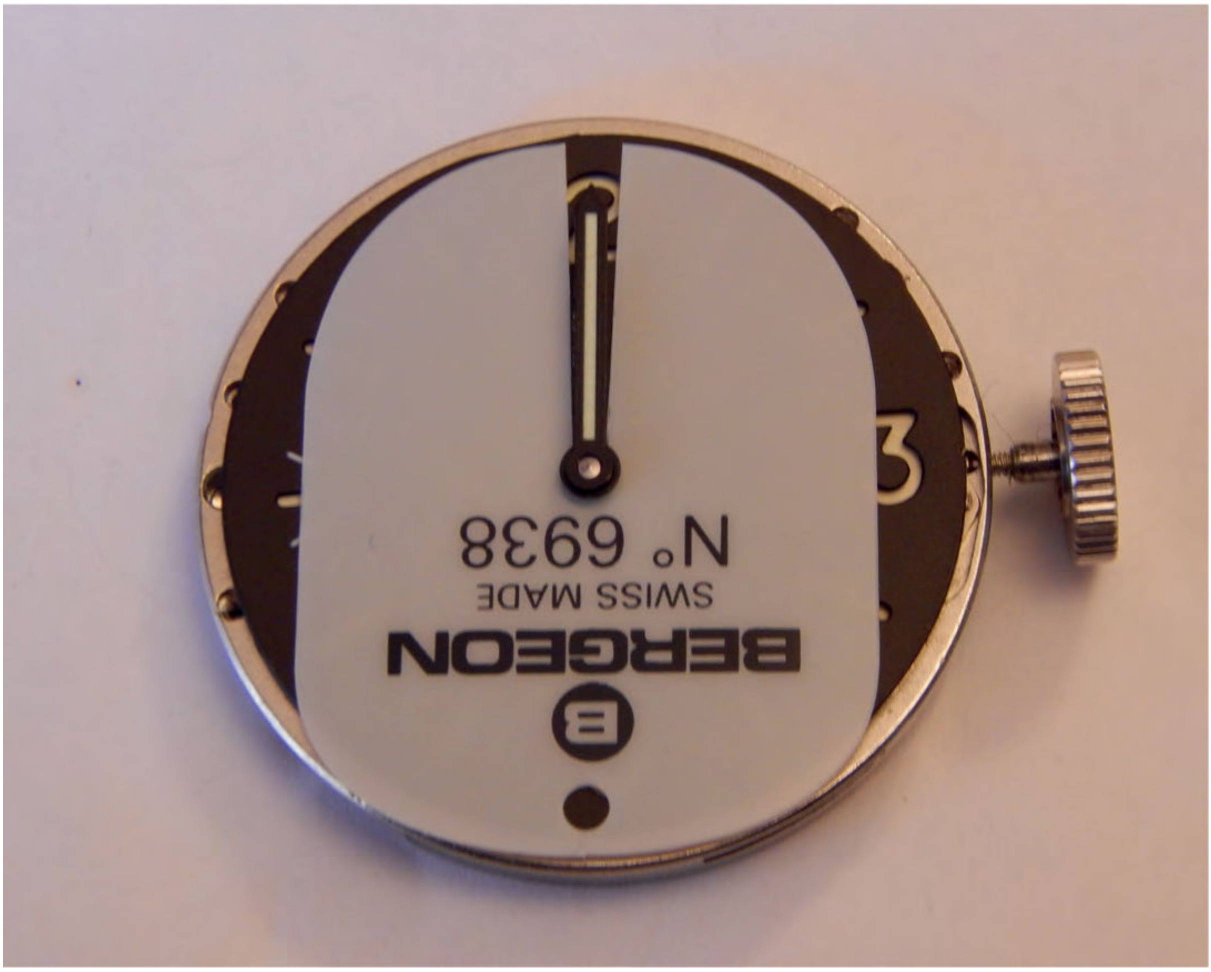


Fig. 62: Dial protector tucked under the hands.

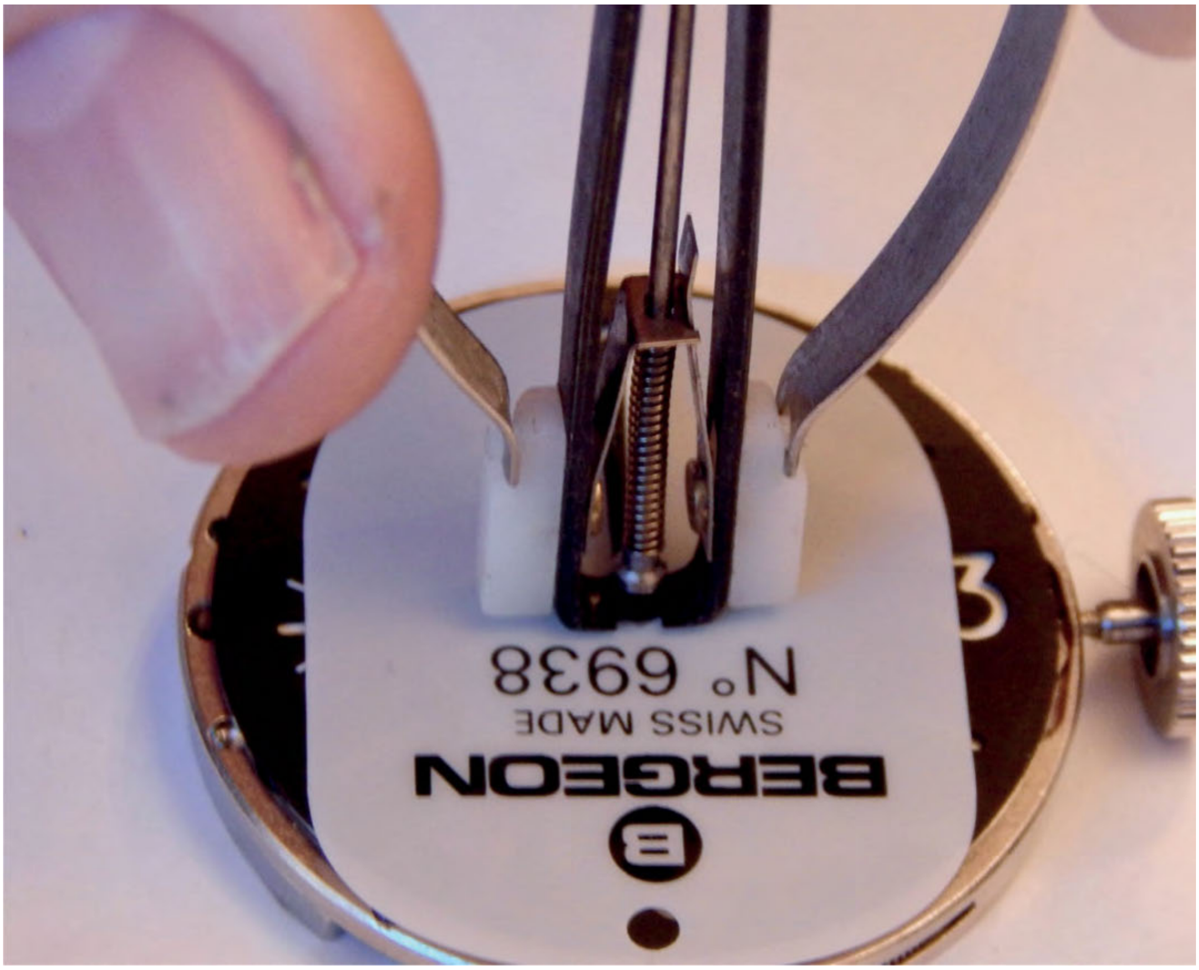


Fig. 63: Jaws of the presto tool cupping the underside of the hour hand. Squeeze the tool and the hands will be removed.

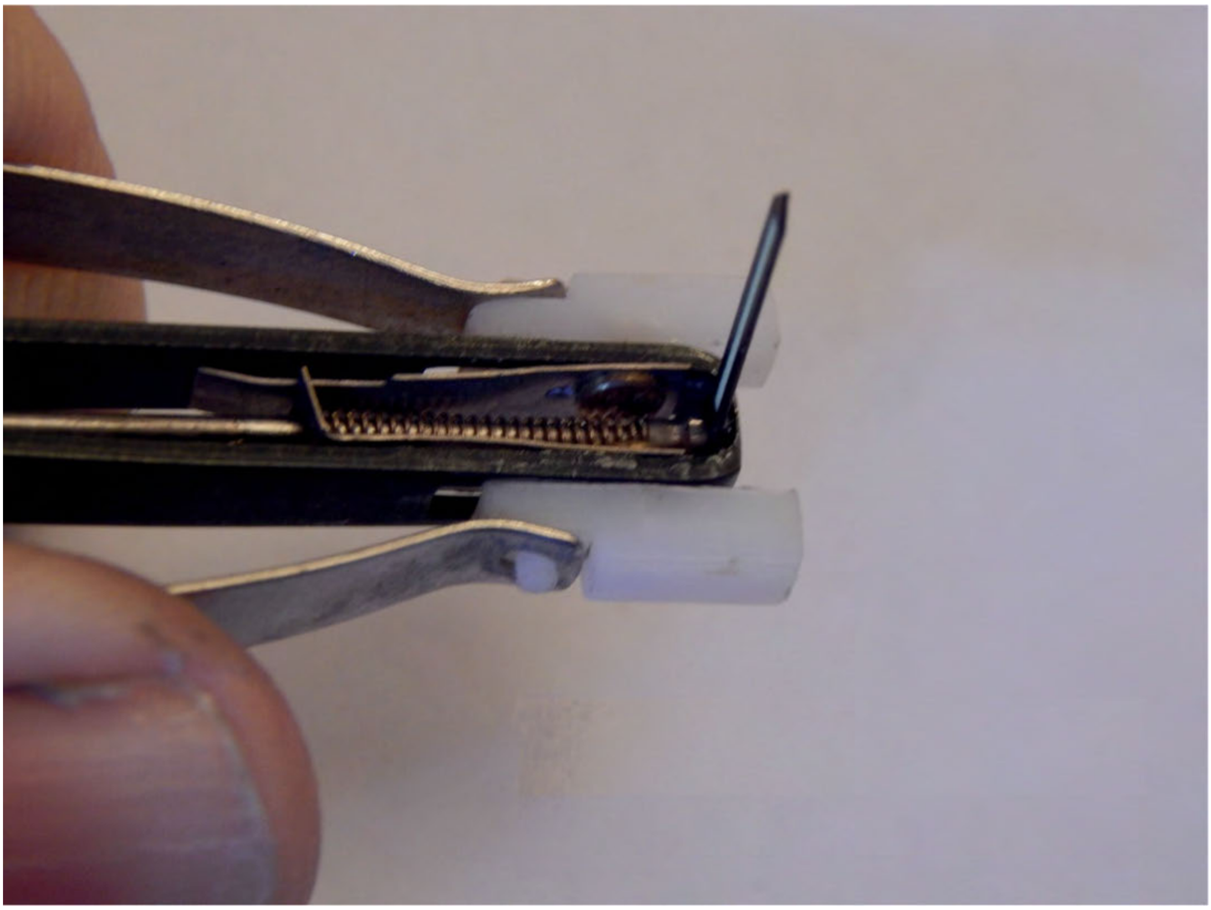


Fig. 64: If you keep pressure on the tool after removal of the hand, it will be held captive in the presto tool by its plunger.

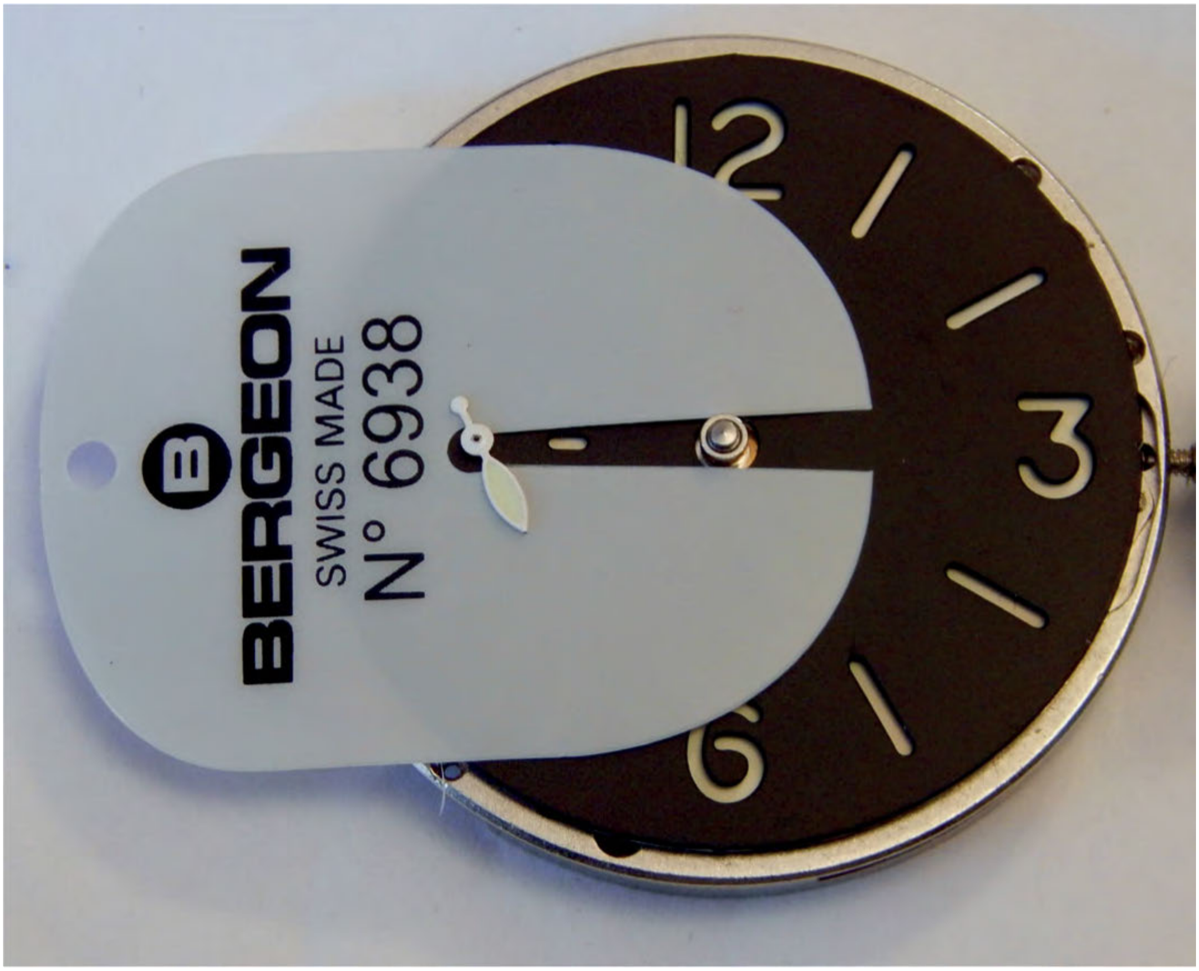


Fig. 65: The dial protector tucked under the subsidiary seconds hand.

Coloured Dials

Black and gloss dials are very easily marked with the Bergeon presto tool, and a stray fingerprint will also be very hard to remove, so finger cots or watch papers must be used when working with coloured dials. The only thing that will remove a fingerprint is a clean, soft cloth similar to a glasses' lens cloth purchased from an optician's, or a Selvyt microfibre cloth from a watch material supplier.

Alternatively, once the dial has been removed, dribble a little washing-up liquid on the dial, then very quickly rinse it off under the tap with cold water, and dry with a puffer (this is not without risk, however). A very clean piece of Rodico will also sometimes remove a fingerprint or a piece of fluff from a dial.

Beware of a watch that has suffered condensation in the case, as this can weaken the bond it has with the dial paint. In the past I myself have accidentally pulled off a piece of paint from a dial and nearly cried. I have also, unfortunately, been given a watch to repair that had been through a washing machine. The dial seemed perfect, so I placed the dial protector on the dial, removed the hands, then removed the dial protector – and to my astonishment, the numbers had disappeared! In fact what had actually happened was that the detergent had reacted with the transfer, which had transferred itself to the dial protector.

This all sounds rather gloomy, but a watch dial is the one thing everyone sees, and if you have an accident everyone will know. As best practice I had the dial restored by a professional dial restorer, and the owner of the watch never knew it had happened, even though it wasn't my fault.

HAND LEVERS

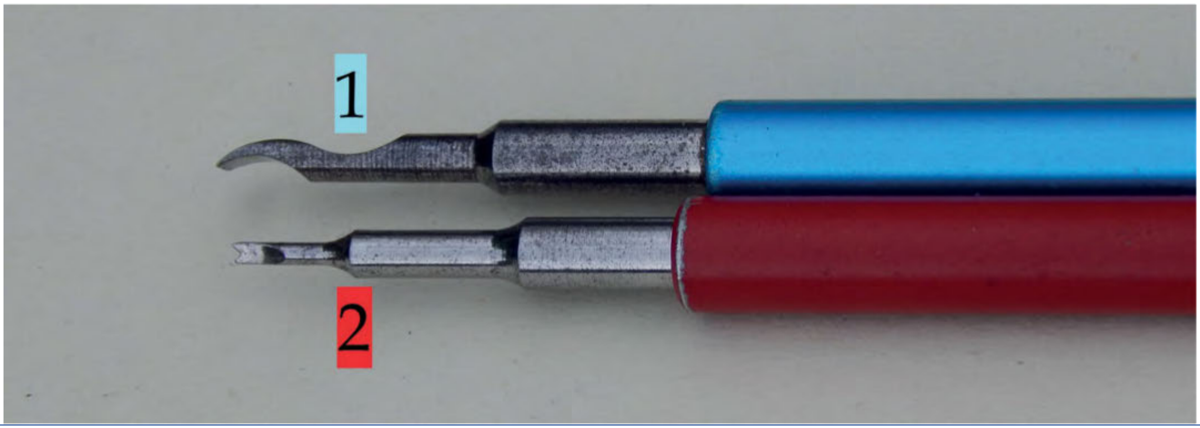
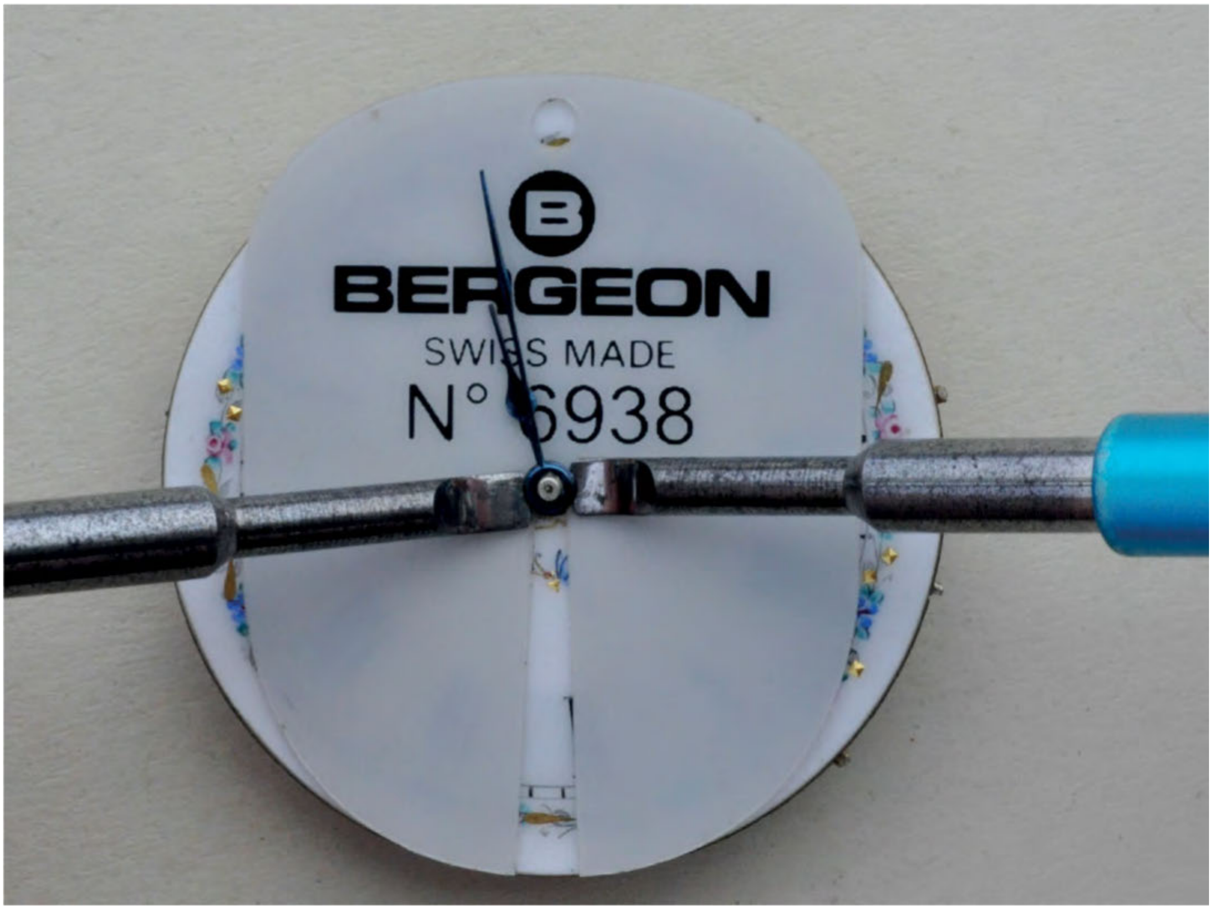


Fig. 66: Two sizes of hand lever – image 1: the regular size; image 2: a smaller size used for the subsidiary seconds hands and the minute recorder hands in chronographs.

For those who are naturally heavy handed I would suggest opting for the presto tool, as it only requires the use of one hand. With hand levers you need to use both hands at the same time, which can present a challenge to the novice. When I first started repairing watches I could never really get on with hand levers, but now I prefer them because you have more control when removing hands, which reduces the chances of marking or distorting them. The main disadvantage as a beginner is lack of dexterity in both hands – unless you are ambidextrous; but don't panic, because the more you practise, the more your eye-to-hand dexterity will improve.



Using Hand Levers

Fig. 67: A pair of hand levers being used to remove the hands.

Place the dial protector between the dial and the hour hand. Place a lever on each side of, and fully under the hour hand, resting the levers on the dial protector, and press both down at the same time. Try to keep both hands moving very slowly, at the same time observing the operation with your eye glass: this means you can stop instantly if you see anything going wrong. As I said previously, the hard part is controlling both of your hands so they perform in perfect symmetry, as any unsolicited twitch may cause damage.

The only down side with levers is if the hands are rather tight. If this is the case, then when they break free they have a tendency to fly up in the air. To prevent this happening, hold the right-hand lever with your thumb and middle finger, and use your free index finger to hover over the top of the hand being removed, so that when it breaks free it will hit your finger and stay on the bench, rather than land on the floor.

12. REMOVING THE DIAL

METHODS OF FIXING A DIAL TO A WATCH MOVEMENT

All watches have some means of fixing the dial, or ‘face’, to the watch movement. The most common method is via two or three little posts welded to the back of the dial; these are called dial feet, and are normally made from copper wire. Most painted dials are made from brass sheet, which is then painted. In the case of antique watches, these are most commonly found with white enamel dials, the dial itself being made of copper. In a few rare cases antique watch dials are made from solid gold or silver, but still have copper feet.

Dial feet are normally located in pairs on opposing sides of the dial, making it easier to find them. Occasionally there may be three, but these are normally found on higher grade watches or American pocket watches. These feet locate in matching holes in the movement base plate, and there is always some type of fastener to hold the dial firm and secure.

Dog Screws

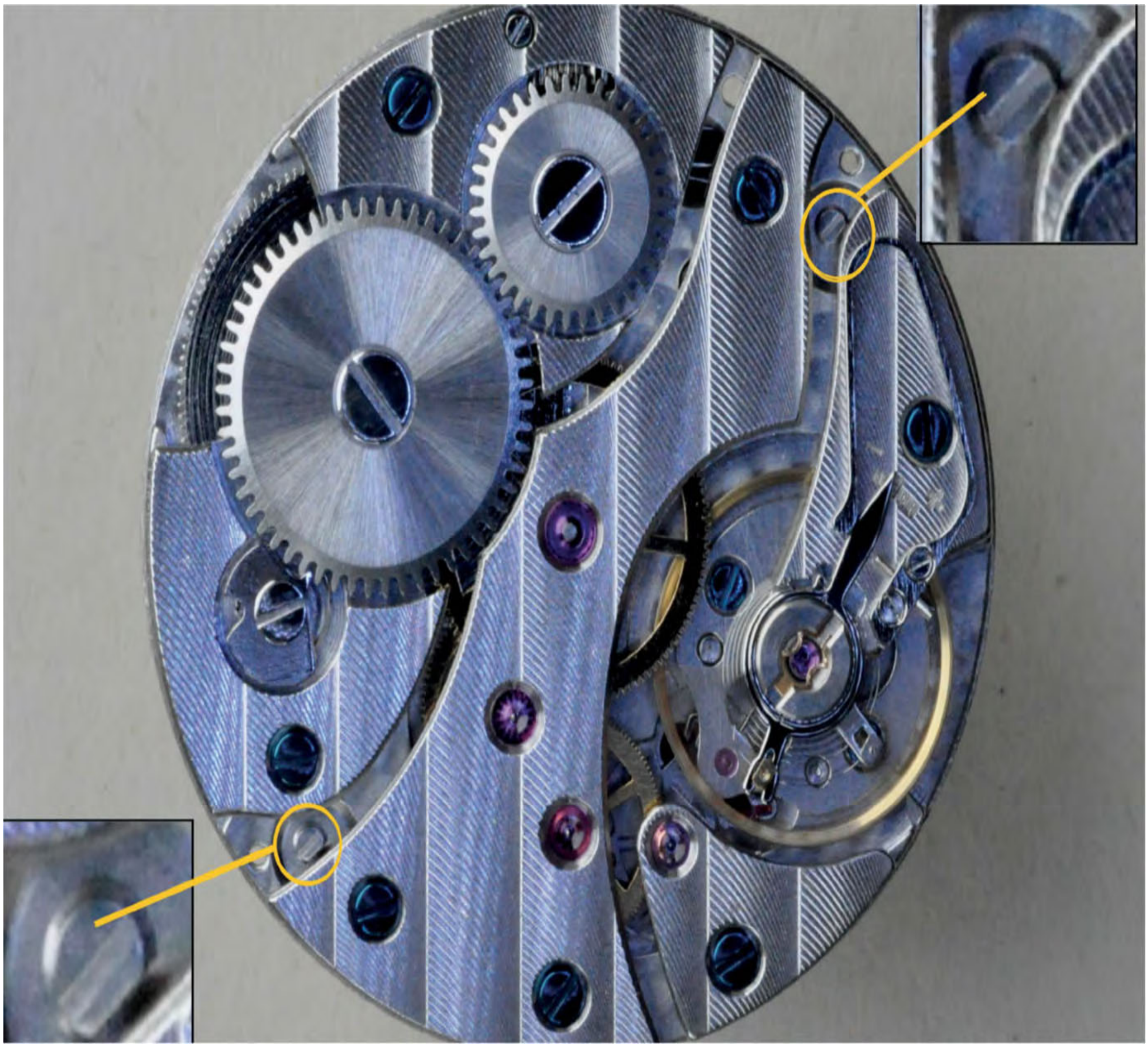


Fig. 68: The position of the dog screws (dial screws) that hold the dial in place.

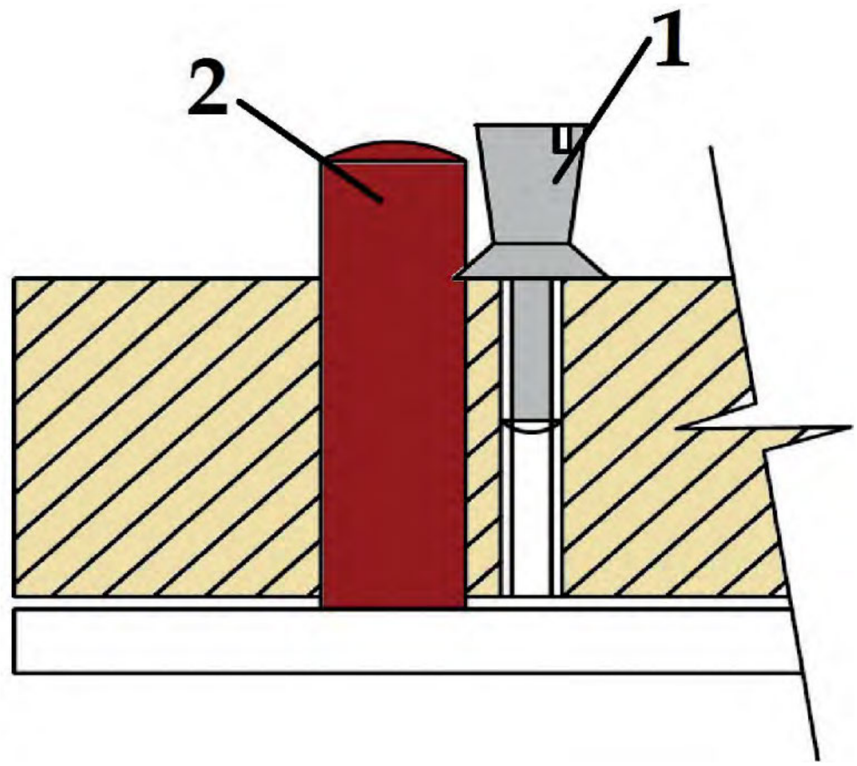


Diagram 2: (1) Dog screw. (2) Dial foot.

A dog screw has a semi-circular disc with a chamfered edge in its middle; this chamfered edge resembles a wheel-type pizza cutter with a bite taken out, as found in many kitchens today. On top of this semi-circular disc is the screw head; this is normally half the size of the cutting-disc top. The size of this type of fastener can vary from 1 to 3mm in diameter. They cut into the side of the protruding dial feet, which extend beyond the plate. As the dial feet are made from soft copper and the screws from hardened and tempered steel, the screw's disc cuts into the side of the dial foot to hold the dial secure.

This type of dial fastener is commonly found in modern Japanese watches such as Seikos, and also in some of the more current Swiss watch movements. It is also very commonly found in watches from the late nineteenth century, though it fell completely out of fashion in the twentieth century.

Finally these dial fasteners can also be found in early French and Swiss watches. These older screws tend to have a taller screw head with a back taper, and the head of the screw extends up from the main plate, level with the top watch plate. This is very unlike their modern equivalent, which are much squatter, so they don't take up a lot of room.

Removing a Dial Fixed with Dog Screws

To release the dial, insert a screwdriver into the screw head and rotate it until the cutting disc is clear of the dial foot. Once you have done this to both dial feet you can then carefully lift off the dial with your fingercotted fingers and place it carefully to one side, dial up.

If you are working on the Seagull movement, the fasteners can be seen from the back, positioned at around 5 and 11 o'clock, as shown in the diagram.

Common Dial Screws

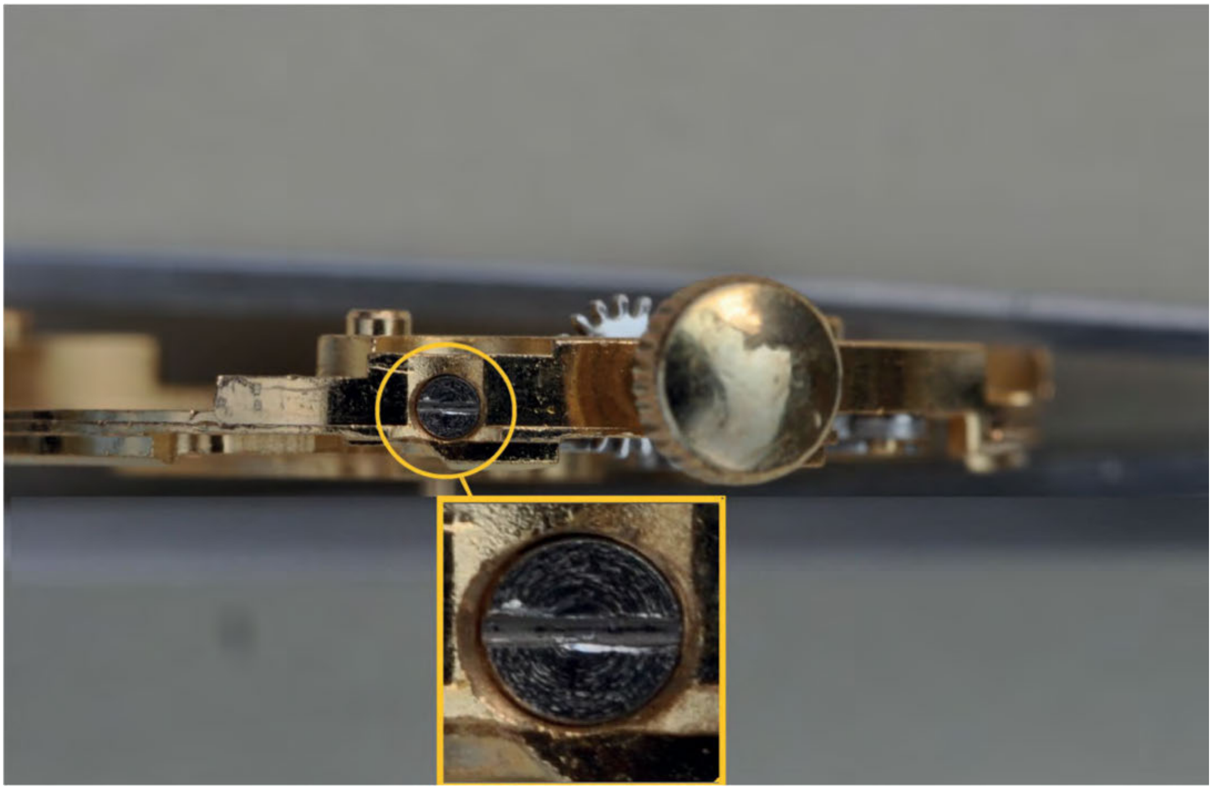


Fig. 69: The position of the more usual dial screw.

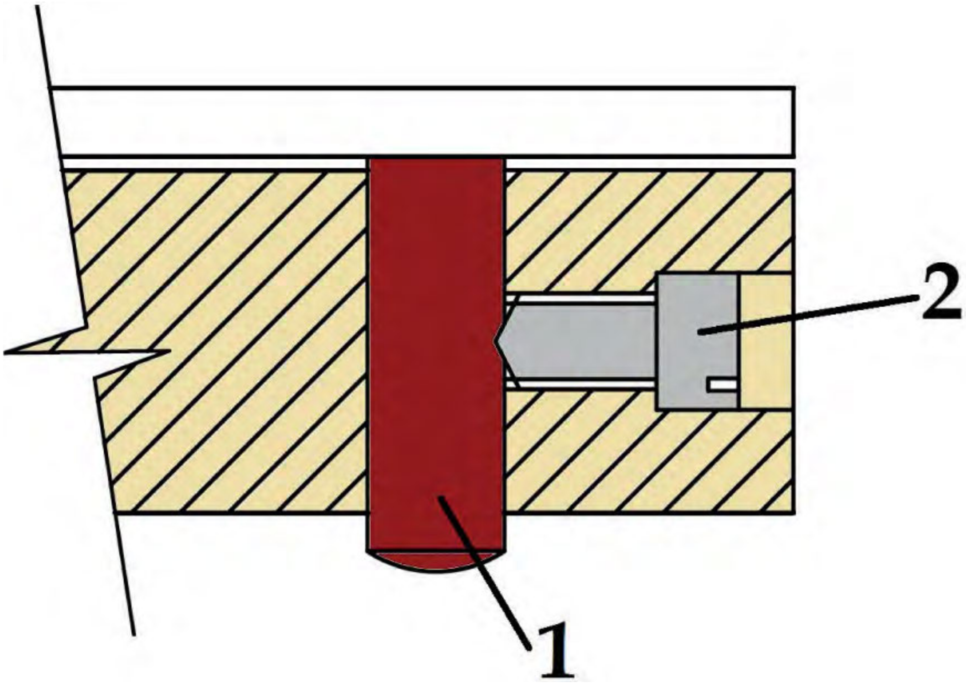


Diagram 3: (1) Dial foot. (2) Common dial screw.

The most usual method of securing the dial to the movement is with common dial screws. Again, they are located on opposing sides of the movement's main plate, but rather than being mounted on top of the main plate, they are located on the outer edge of the plate, in recessed holes. The screws' threaded tips have been ground to a sharp point, so when they are tightened their points dig into the side of the dial feet. To remove the dial, you only need loosen the screws one and a half turns, and no more. The dial can then be carefully lifted free from the movement.

Tip: Once the dial is free of the movement and you intend to clean the watch, I would recommend tightening up the screws in their holes. This is because they can be easily lost during cleaning and are hard to replace unless you have a good supply of assorted dial screws, or access to spare parts.

Plastic Sleeves or Grommets

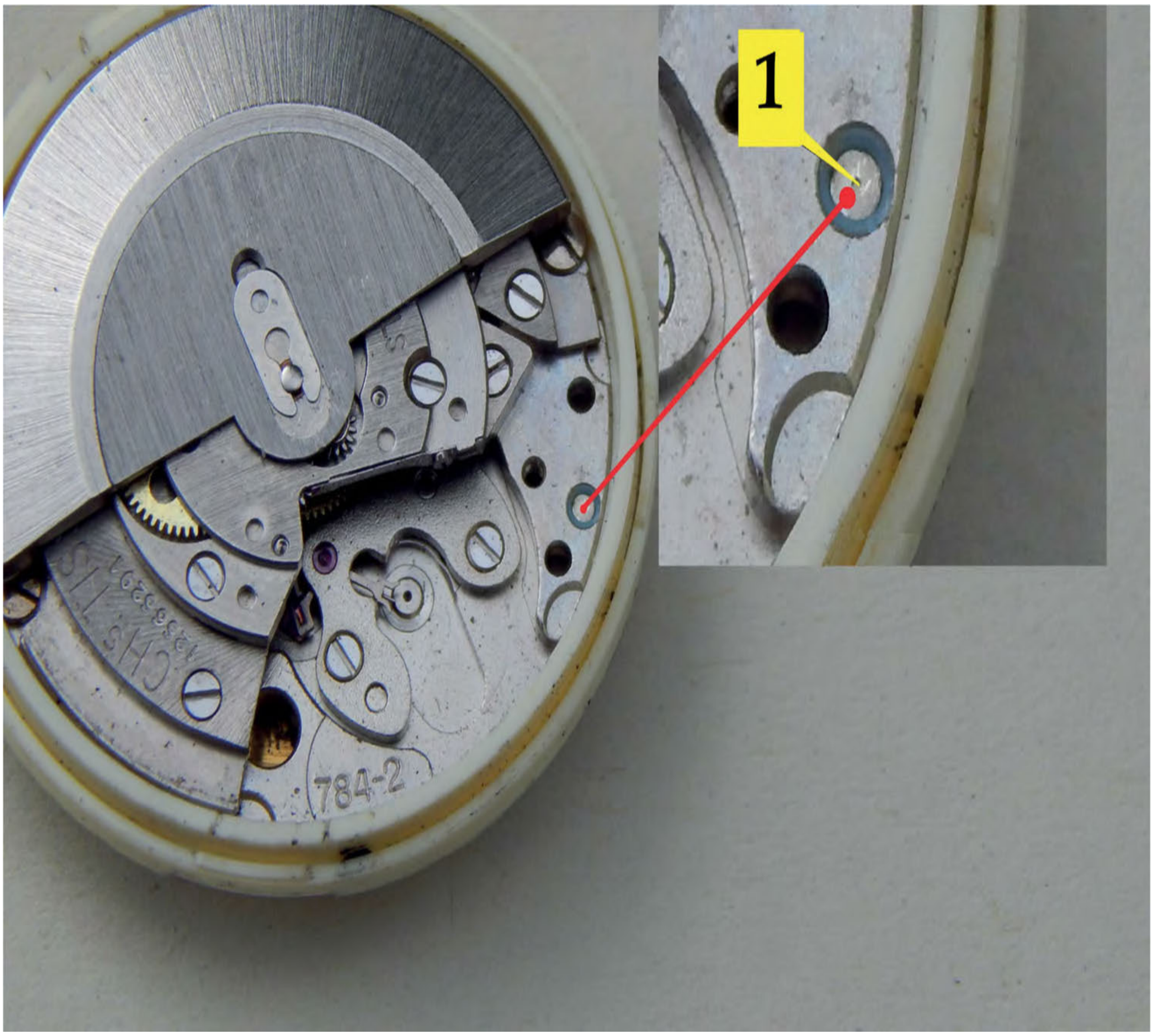


Fig. 70: The less common dial grommet found in the Tissot 784.

A lot of modern quartz watches have dial feet that just push into plastic sleeves, which themselves are simply pressed into the movement. These sleeves grip the dial feet and hold everything in place. You can also find this system in 1970s mechanical movements. The only way to remove the dial is to lightly lever up the dial with a screwdriver blade.

ETA Dial Fasteners

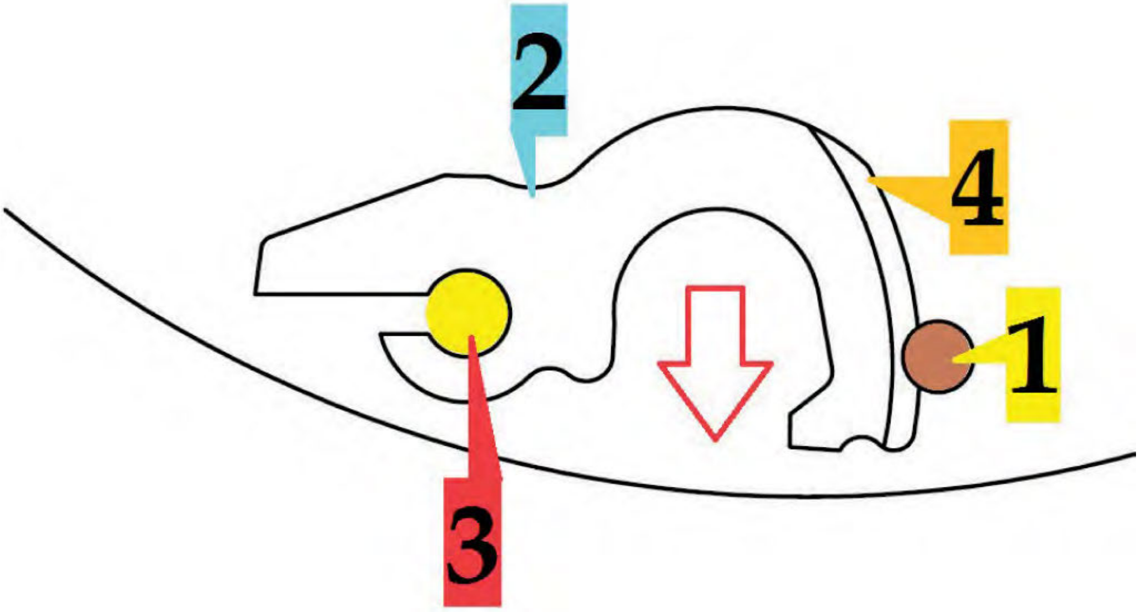


Diagram 4: Eta dial fastener. (1) Dial foot. (2) Fastener (lobster claw). (3) Hinge point. (4) Edge of the fastener.

The ETA dial fastener is a fairly modern type of fastener resembling a question mark in shape, and placed in a similar position to dog screws. It is commonly found on Swiss ETA movements from the 1980s up to the present day. This style of dial fastener seems to have gone out of fashion in recent years. I suspect they were introduced to cut costs in manufacturing as this part could be stamped out of sheet metal. This is probably why they are less common in the more modern type of movement being made today, as the quality of watches these days seems to be improving. It is a similar idea to the dog screw, but they present in the form of a lever which swings in and out to grip or release the dial feet. They are less destructive than dog screws because they do not cut into the dial feet, the question mark shape of the lever acting more like a spring to hold on to the dial feet.

Tapered Pins

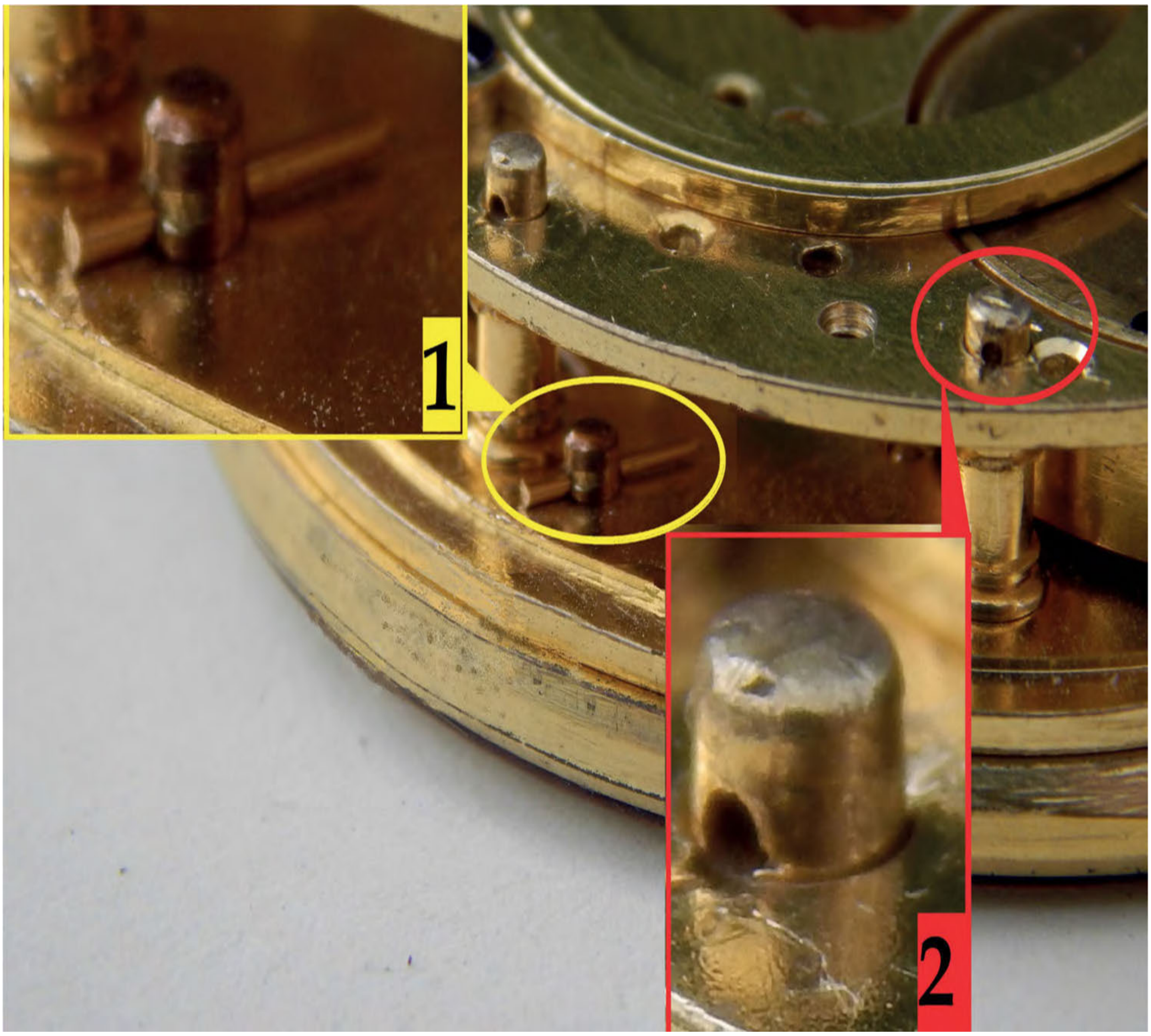


Fig. 71: An early pocket watch held together with brass taper pins. Image 1: a fitted taper pin. Image 2: the hole in which the pin is fitted.

The oldest method of fixing a dial to the movement is to have holes drilled through the sides of the feet just above where they protrude through the base plate. To secure the dial a small tapered brass pin is pushed through each hole until it is a tight fit.

Bezels

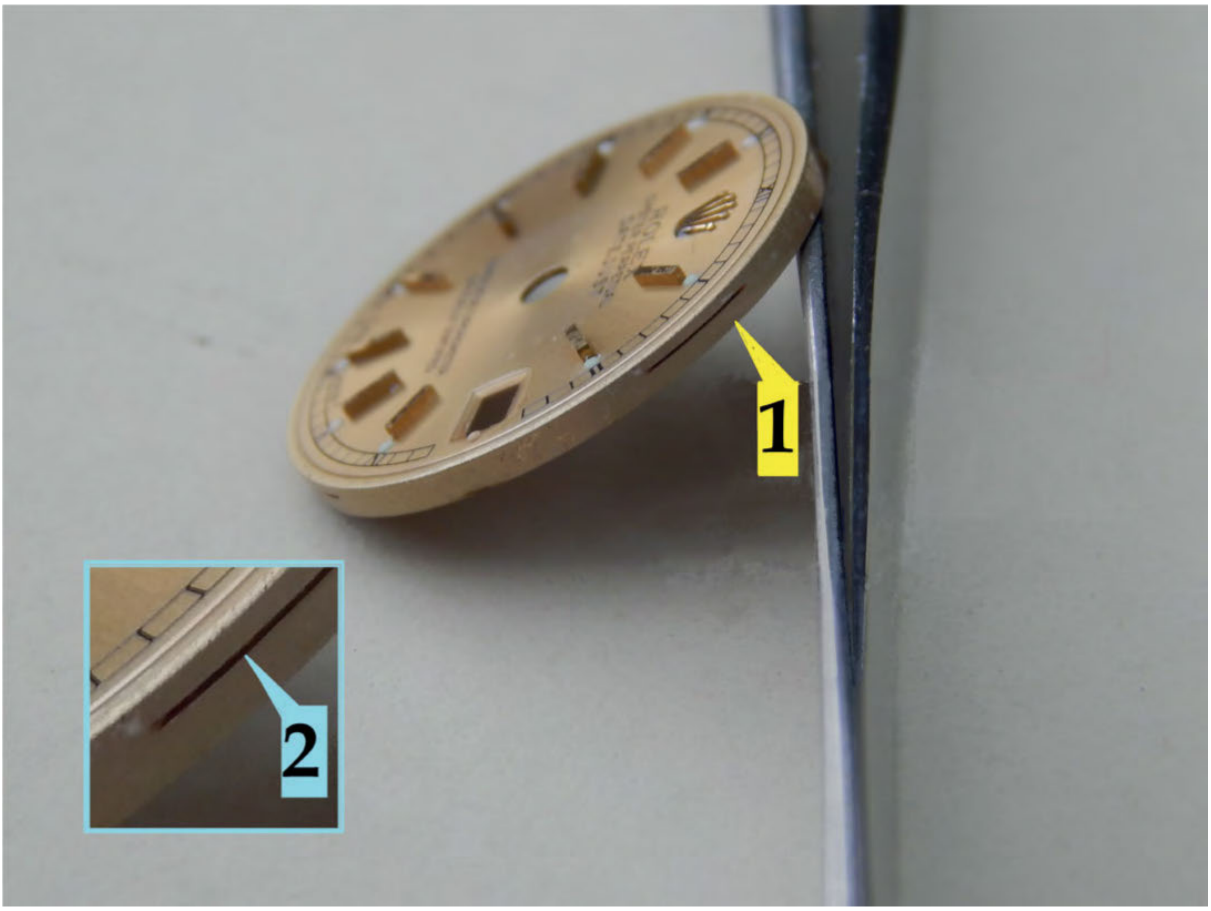


Fig. 72: A bezel-secured dial by Rolex. Image 2: the slit cut into the rim. There are two of these on the dial, on its opposite sides. They are used to tension the dial so it clips on tight to the movement.

The bezel-secured dial is the odd one out and yet probably the most satisfactory method of fixing a dial to a watch movement, as the dial will always be positively centred. This type of dial has no dial feet, and works like a Tupperware lid, with the dial simply clipping on to the movement by way of an extra rim on its outer edge, making it somewhat like a cup.

This type of dial is only ever found on antique repeater pocket watches, some Rolexes and cylinder pocket watches. It is not a popular method because it considerably increases the manufacturing cost.

Counter-sunk Screws

Not to be confused with common dial screws, this type of fixing has no dial feet. The outer edge of the dial is drilled with two or more vertical holes. These holes will match up with holes in the watch’s movement main plate, and the dial will be secured to the movement by very tiny counter-sunk screws. This is the favoured method of securing the dial to the movement by some high grade watch manufacturers, and in watches that have been made by hand. The only down side is, if a watch repairer is a little clumsy, they will inevitably mark the dial when removing the dial, or the small screws may be lost as they are genuinely very tiny.

Warning: Always make sure you understand how to remove the dial, and never resort to just prising it off.

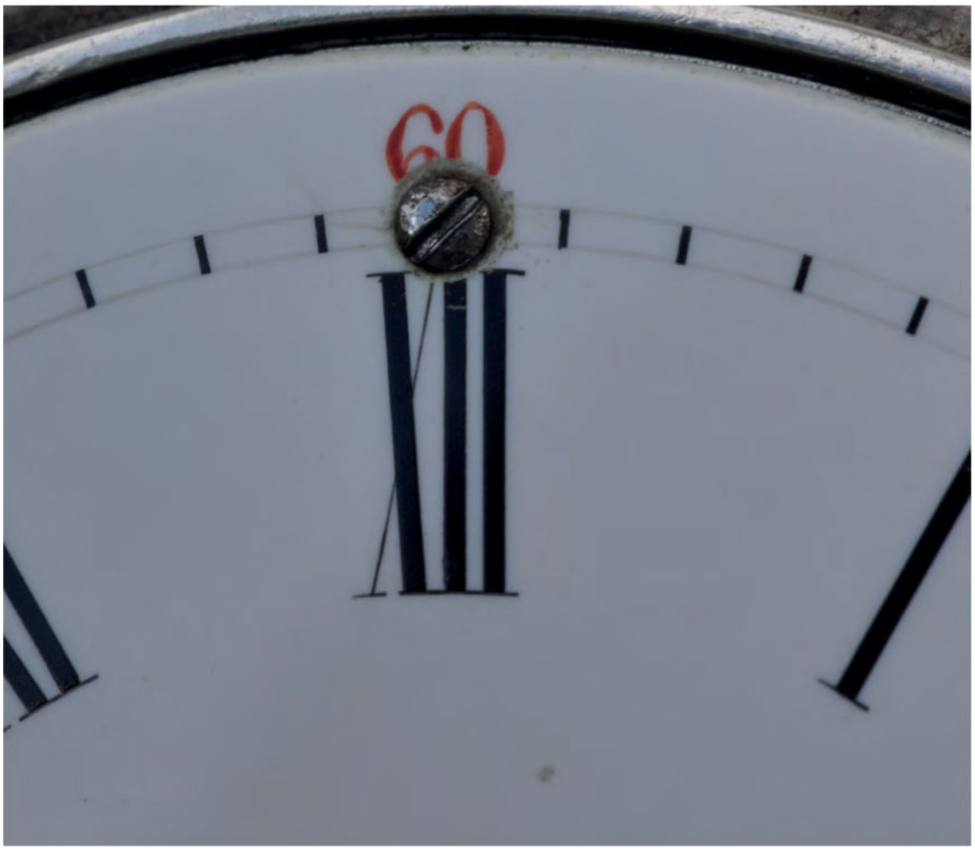


Fig. 73: A dial secured by two screws, one at 12 o’clock and the second at 6 o’clock.

WHAT’S UNDER THE DIAL?

Once you have removed the dial you will see two things of interest: keyless work and motion work.

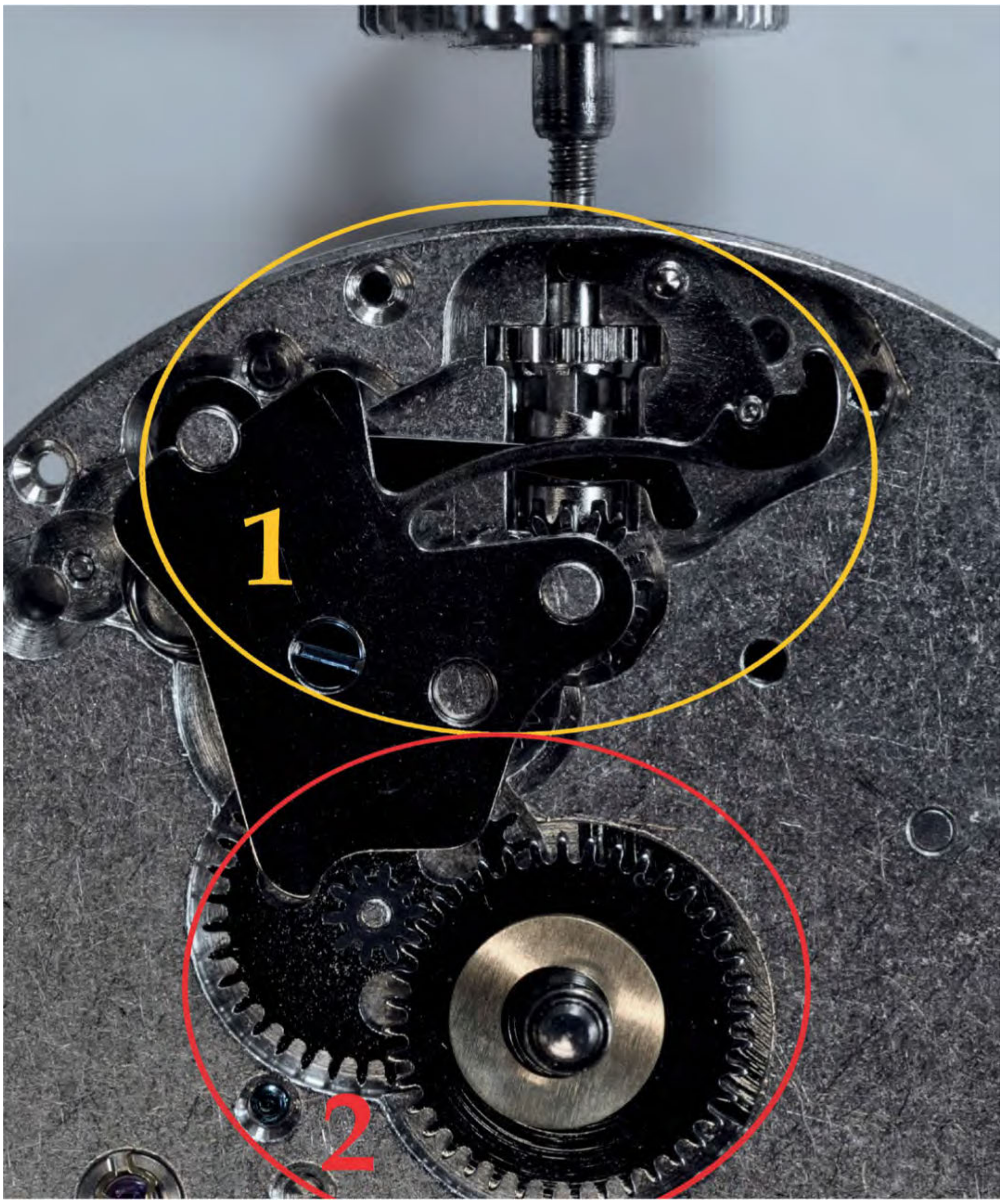


Fig. 74: Image 1: the keyless work. Image 2: the motion work.

Keyless work: This is the mechanism that is driven by the winding stem, and the button that it is fixed to. When turning or pulling on the button, the job of the keyless work is to allow the owner to set the time of the watch and to wind the main spring. In some cases there may also be some sort of fast day or date change, if the watch has a calendar.

Motion work: This is a set of gears in the centre of the movement, which provides drive for the hands. These are driven by the centre wheel, the second gear in the gear train (gearbox in layman's terms). The minute hand is driven directly from the centre wheel, which rotates once in an hour, and the hour wheel, which turns once every twelve hours, is driven by additional gears, coupled off the centre wheel. This gives you a ratio of 12:1. (This will be discussed in much more detail further on in this book, so don't worry if this isn't clear to you now.)

13. THE MOTION WORK

To get a closer look at the motion work you will have to remove the hour wheel and its dial washer. This is the large wheel in the centre of the watch; lift this upwards with your tweezers, grasping it by its tube. As you lift off the wheel there should be a very thin brass or copper washer which has been curved at its centre, resting on top of the wheel (this is a separate part and can easily float away).

Now, I would like to draw your attention to the exposed cannon pinion which was hidden underneath the hour wheel.

THE CANNON PINION

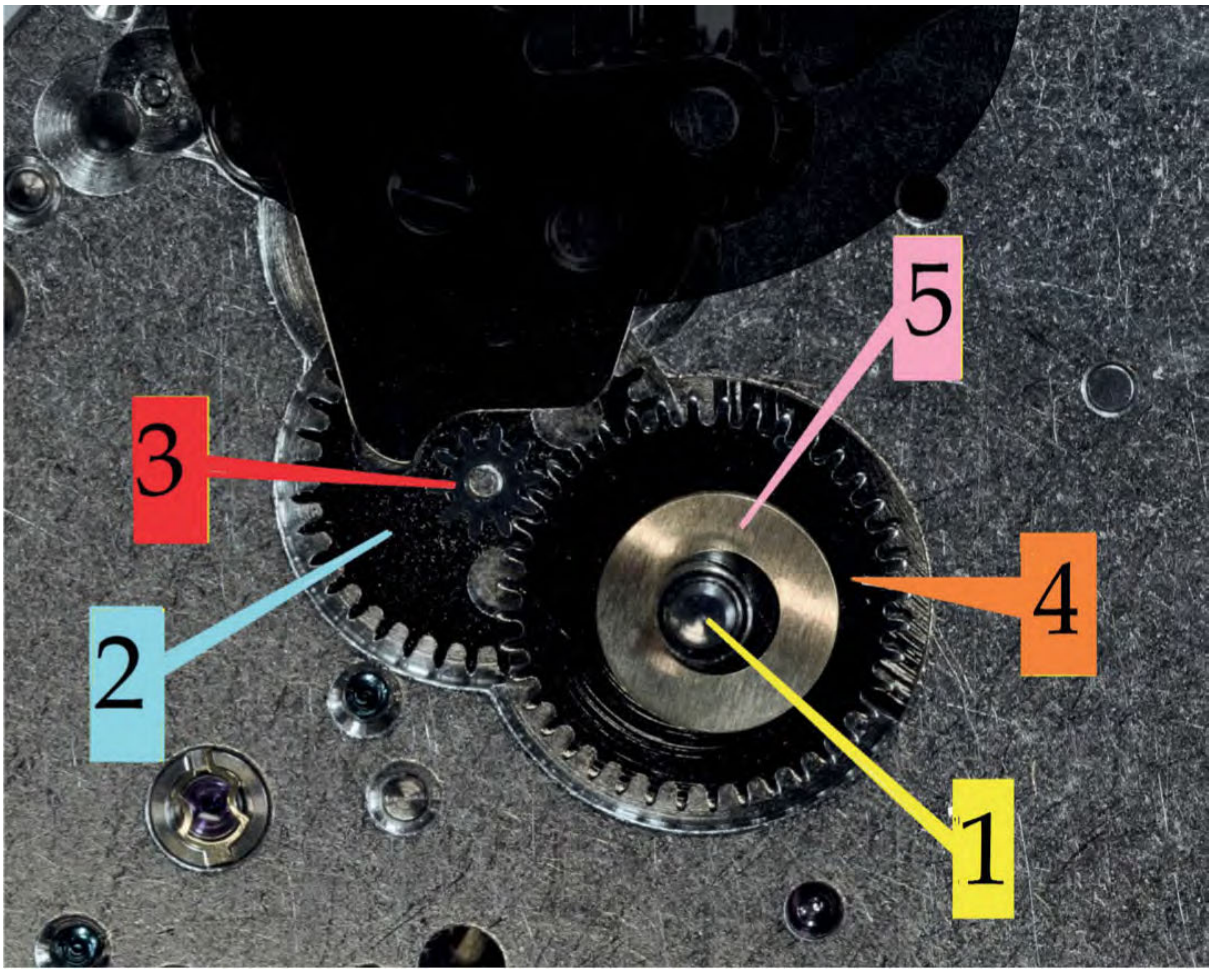


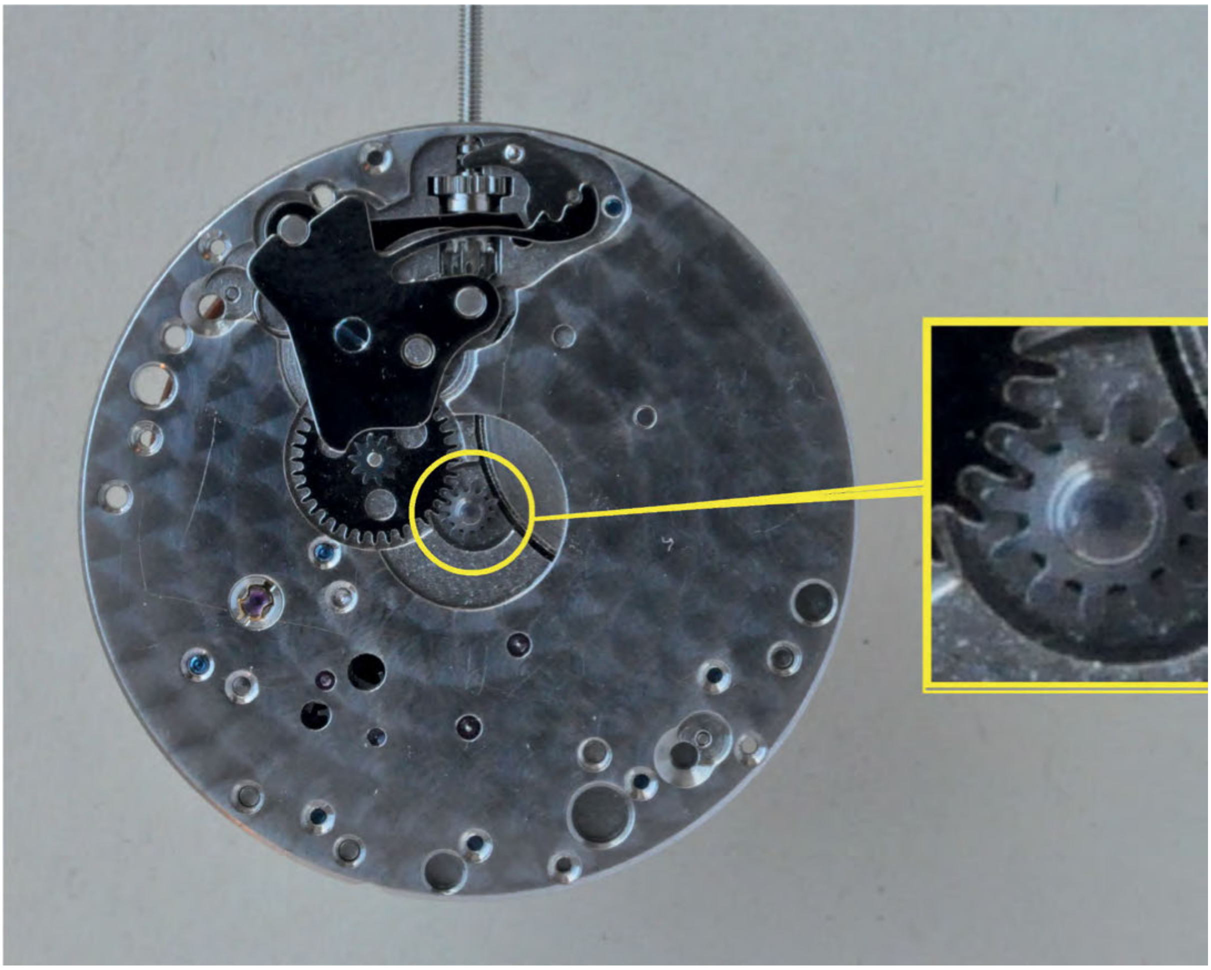
Fig. 75: The motion work: 1: cannon pinion. 2: minute wheel. 3: minute-wheel pinion. 4: hour wheel. 5: dial-spring washer.

The cannon pinion is basically the clutch for setting the hands of the watch to the correct time. Logically, you need to have something that can slip allowing the hands to be moved, without turning the gears in the gear train. It must also have enough grip to allow the watch hands to turn during normal running without prematurely slipping.

The cannon pinion is basically a steel cylinder with a waisted section in its middle. At its base there is a steel pinion (cog or gear in layman's terms) which supplies the drive for the hour hand via the minute wheel. If you look closely at it, the cylinder has two segments that are reduced in diameter: the top segment allows the minute hand to be pressed on to its end, and also prevents the hand from being pushed down too far. This pinion normally has six or more teeth.

Put the watch into hand-set mode and turn the crown, as if you were setting the time, and the cannon pinion will rotate. Turn the watch over and look at the back: the large gear in the middle of the watch (the centre wheel) remains stationary. Again, logic dictates that something is happening inside the cannon pinion.

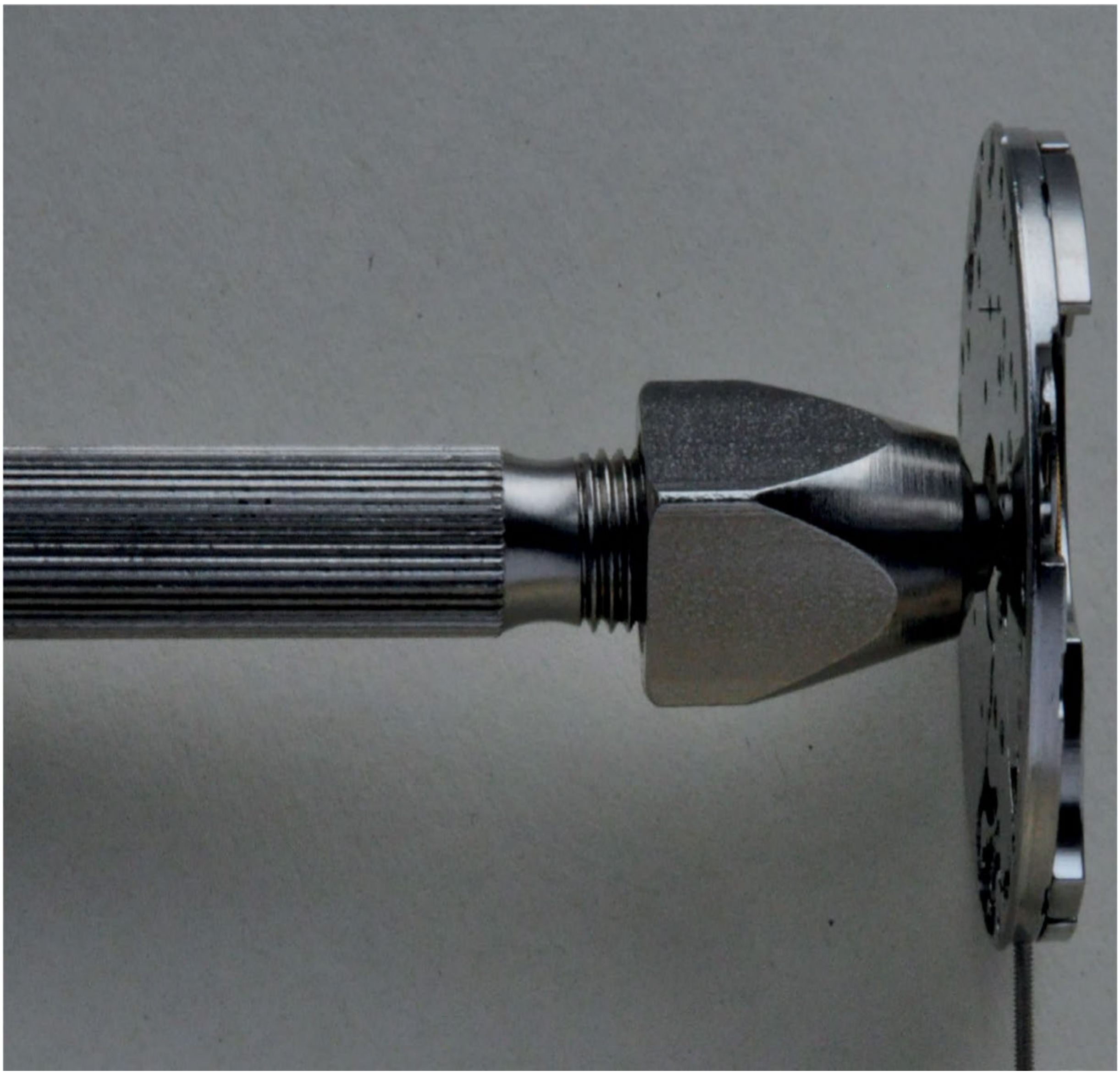
To understand how this functions, you will need to look closely at the centre wheel pivot. To do this you will have to remove the cannon pinion.



Removing the Cannon Pinion

Fig. 76: The cannon pinion revealed by the removal of the hour wheel.

There are two methods of removal: with a pin vice, or with Bergeon presto lift hand removers.



Using a Pin Vice

Fig. 77: Pin vice fitted to the shaft of the cannon pinion.

Take a pin vice and lock it round the shaft of the cannon pinion (not the teeth), making sure that it is nice and tight. Use one hand to hold the movement firmly and the other hand to grip the pin vice with your thumb and index finger. At the same time, rest both of your wrists on your torso. Next, twist and pull on the pin vice whilst holding the movement firm, making sure not to touch the balance wheel. It will require a certain amount of force to remove the cannon pinion, similar to opening a tin of beans with a ring pull. With the Seagull ST25 movement the cannon pinion may be really tight, and it might take a couple of attempts to remove it. Conversely, you may find that the pin vice just pulls off the cannon pinion. This is normally because the pin vice hasn't been sufficiently tightened, or it may simply be a reflection of the quality of the tool you have.

If you struggle to remove the cannon pinion, just try and keep calm, have a break, and then try again. If you don't trust me, things will undoubtedly go wrong and you will feel like smashing the watch in anger or just giving up entirely. However, although it may seem hard at first, if you persist, things will soon get easier; just like driving a car for the first time, there is always a lot of information to take in.

If your pin vice is new and persists in riding over the cannon pinion, try unscrewing the top and dropping a smear of oil on the outside surface of the jaws (any oil will do). This will help the jaws compress and will ultimately make the pin vice close up tighter around the cannon pinion.

Using Bergeon Presto Lift Hand Removers

An alternative way is to use the Bergeon presto lift hand removers, or you can get the Bergeon presto cannon pinion remover, which is almost identical to the hand removers, but is slightly more robust.

Place the jaws of the tool in the waisted part of the cannon pinion, with one hand squeezing on the lower part of the tool to keep the jaws tightly closed round it. This is key to removing it.

With the other hand, squeeze the middle part of the tool. If you perform this correctly the pinion will be lifted off in one move.

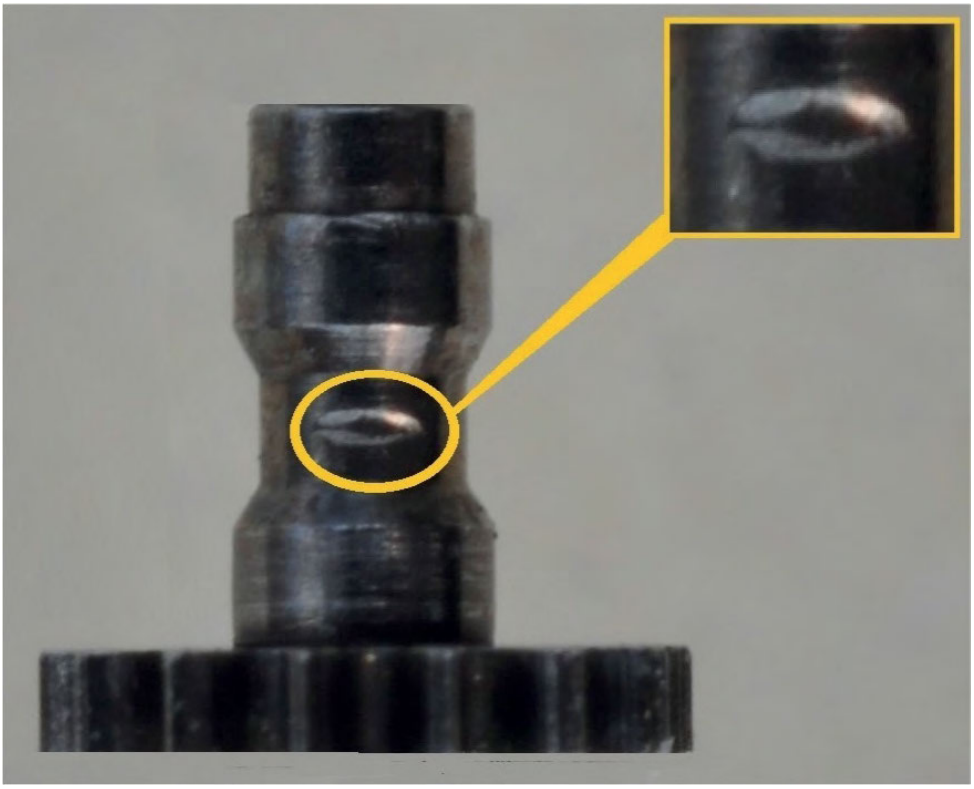


Fig. 78: The dent on the surface of the cannon pinion.

Now that the cannon pinion has been removed, we can have a closer look at it. In the middle section where it is thinnest, there is a dent on its surface: this dent has been put there by the manufacturer, to create a bump on the inside of the cannon pinion's tube. This is where the friction comes from, as this small extra surface squeezes on the centre wheel's pivot, making the cannon pinion a tight friction fit. With the aid of oil, this means that the cannon pinion can rotate stiffly without snapping the centre wheel's extended pivot or turning the gear train.

Warning! Do not try refitting the cannon pinion without reading the rest of the chapter: if you try refitting it now, there is a high chance that you will shear off at least one of the teeth of the minute wheel!

THE CENTRE-WHEEL PIVOT

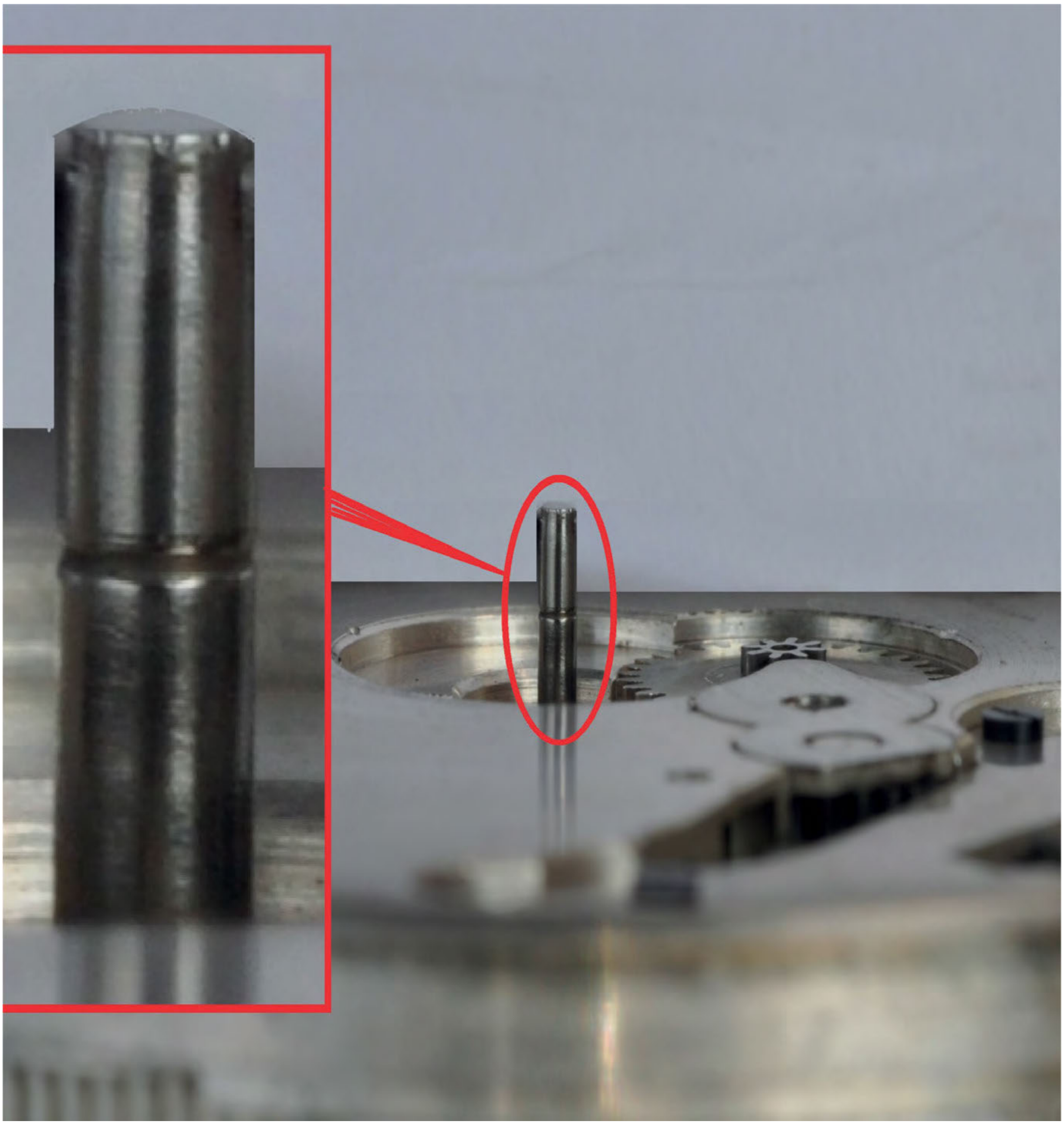


Fig. 79: The snap groove on the centre wheel.

Look back to the movement: the removal of the cannon pinion has now revealed the centre-wheel pivot. With the Swiss movement, look at the pivot about one third down its shaft with a strong eye glass. You should see it has a slightly waisted section with a slight back taper in the middle third of the pivot's length.

If you are using the Seagull movement, you will just see a groove running horizontally round the middle portion of the centre wheel pivot. This groove, or back taper, is for the cannon pinion's dent to snap into and draw it home to the base of the shoulder of the centre wheel's pivot. The bump on the inside of the cannon pinion locates in this groove/back taper to stop the cannon pinion from naturally trying to rise off the centre wheel's pivot when it is being turned during hand setting. This system has the advantage of creating a very small surface area of contact, preventing the two surfaces from binding. The contact is still strong enough for the centre wheel to turn the cannon pinion without anything slipping when the watch functions normally. The cannon pinion is still able to turn in either direction with ease when setting the hands without any interference to the centre wheel.

Early keyless watches never had the snap groove on the pinion or the back taper on the centre wheel arbour. Instead, the extended portion of the centre wheel's pivot would have had a small hole drilled sideways (parallel to the dial) at the very end. A small tapered brass pin was then passed through the hole and forced into it, making a friction fit. This would stop the cannon pinion from rising. However, this posed a significant problem when watches became smaller, so they had to dispense with the pin and had no choice but to find an alternative solution.

THE MINUTE WHEEL AND ITS PINION

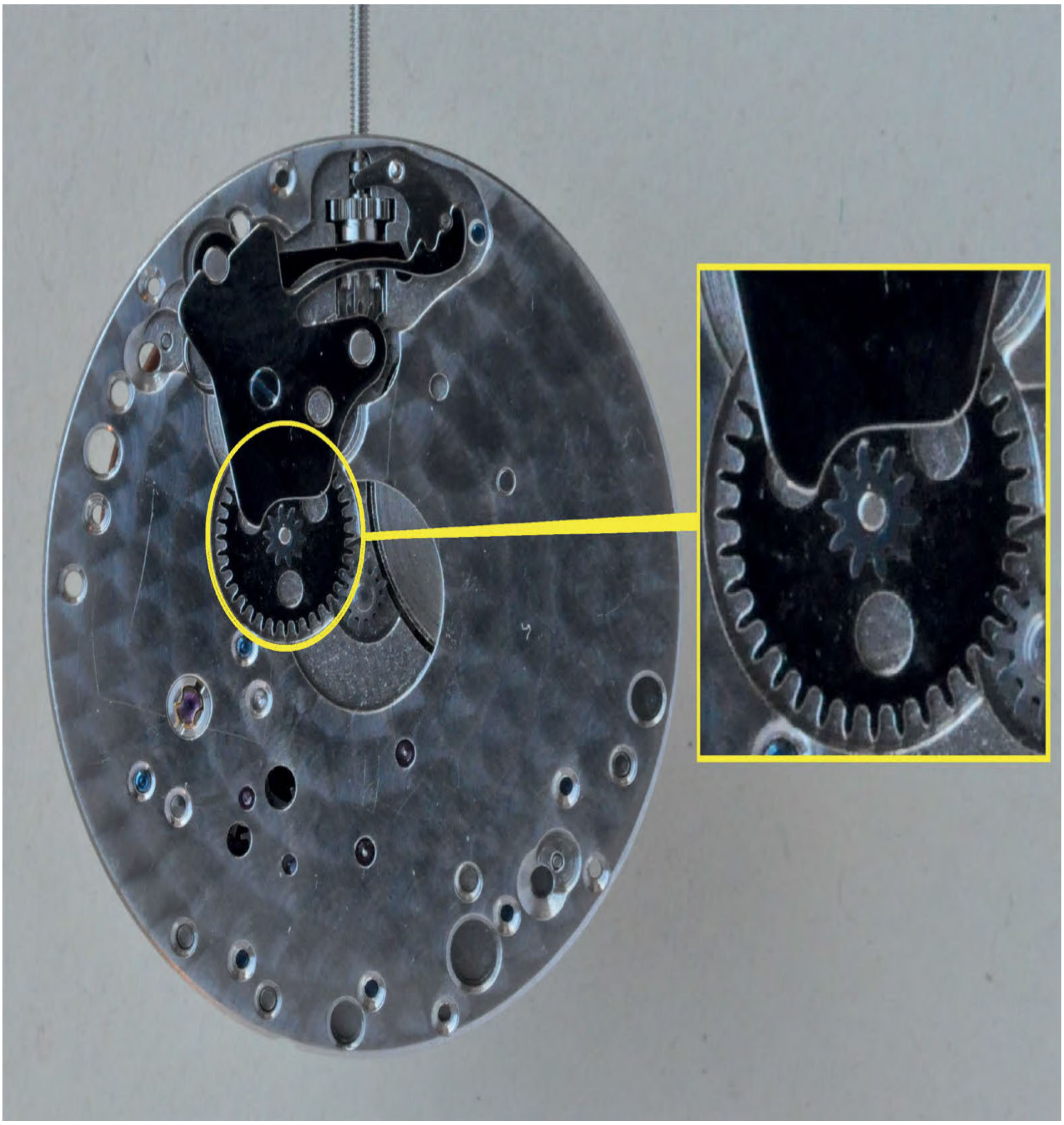


Fig. 80: The minute wheel and its pinion.

The minute wheel is the wheel that was next to the cannon pinion before you removed it. To make things more confusing, the minute wheel does not drive the minute hand as its name suggests: it is driven by the cannon pinion, which drives the hour wheel via the minute wheel's pinion. It also changes the speed of rotation to give us the twelve turns of the cannon pinion to one turn of the hour wheel.

Note that the minute-wheel pinion is riveted to the minute wheel, and that the two form one part. Also, the minute wheel has a hole in the centre of the pinion. This sits on a post/pin which is fixed to the base plate of the watch, and the wheel can rotate freely on it. The reason why it is called the minute wheel goes back to the early days of clock making when the first clocks only had one hand and the centre wheel was geared to turn one revolution every twelve hours. In the pursuit of more accurate measurement of time, it became necessary to incorporate an additional hand, and the gear train was changed to rotate once every hour instead of once every twelve hours. An extra wheel was added and named the minute wheel, which drove the hour wheel one revolution to that of twelve of the minute hand.

THE HOUR WHEEL

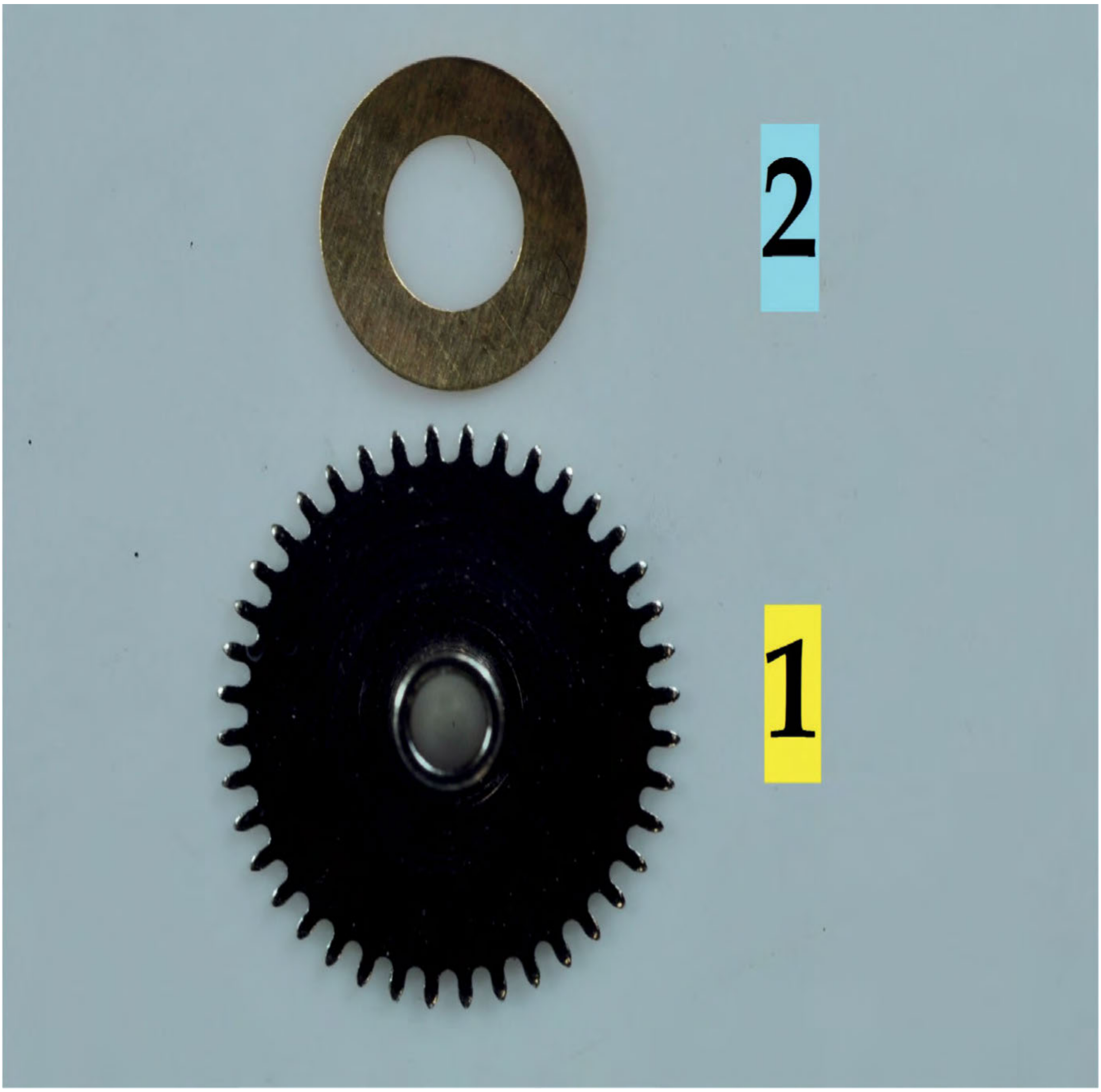


Fig. 81: Image 1: the hour wheel. Image 2: the dial washer.

This wheel is logically and correctly named as the hour hand pushes on to its tube. Its construction consists of a hollow pipe or tube which is attached to the hour wheel. The hour wheel slides over the cannon pinion and can rotate freely in this when driven by the minute wheel.

Hour Wheel Spring (Dial Washer)

This is the brass washer that sits on top of the hour wheel. There is a crease in its centre, making it look as if it has been folded in half. It is made from brass that has been hardened until it has become springy. It sits around the pipe and lies on the hour wheel, curving upwards to push on the dial.

The purpose of this spring is to make sure that the hour wheel does not ride up the pipe of the cannon pinion, allowing the hour wheel to disengage from the minute-wheel pinion. It also prevents the hour wheel from free-wheeling or spinning, and keeps it engaged with the minute-wheel pinion. If the spring were missing or very weak, and the watch turned so the dial was facing down, the hour wheel would slump towards the dial, allowing the hour wheel to disengage from the minute-wheel pinion. The weight of the hour hand would cause it to freewheel around the dial like a roulette wheel. This will cause erratic time keeping or an hour hand that rests between two hours.

THE LOGIC BEHIND THE MOTION WORK

To understand the logic behind the motion work, we have to understand the numbers.

We know that the centre-wheel arbour turns once in an hour. As the cannon pinion is friction-fitted to this arbour, so the two rotate as one. Likewise the minute hand, which is fixed to the end of the cannon pinion, also rotates once in an hour. The cannon pinion’s pinion meshes with the minute wheel to rotate it and its pinion to drive the hour wheel. The hour wheel has a hand on it, called the hour hand, which rotates once every twelve hours.

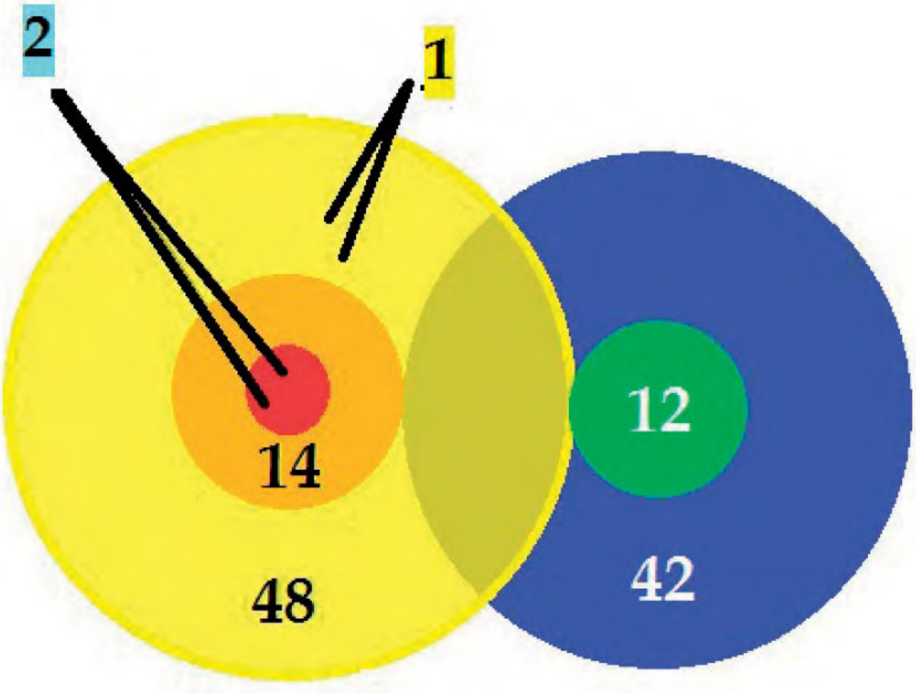


Diagram 5: Motion work. 1 Hour hand; 2 Minute hand.

The number of teeth varies from movement to movement, so here is an example:

Cannon pinion fourteen teeth (red); minute wheel forty-two teeth (blue); minute pinion twelve teeth (green); hour wheel forty-eight teeth (yellow).

There is a three-to-one reduction with the cannon pinion and minute wheel, and a four-to-one reduction with the minute pinion and the hour wheel, making a twelve-to-one reduction in all.

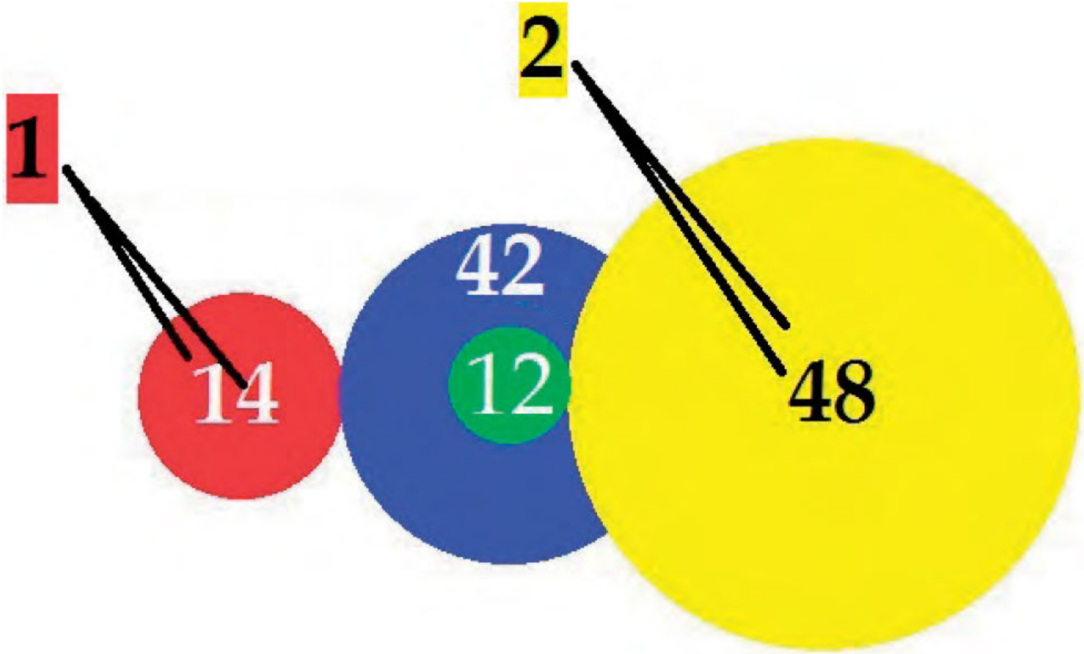
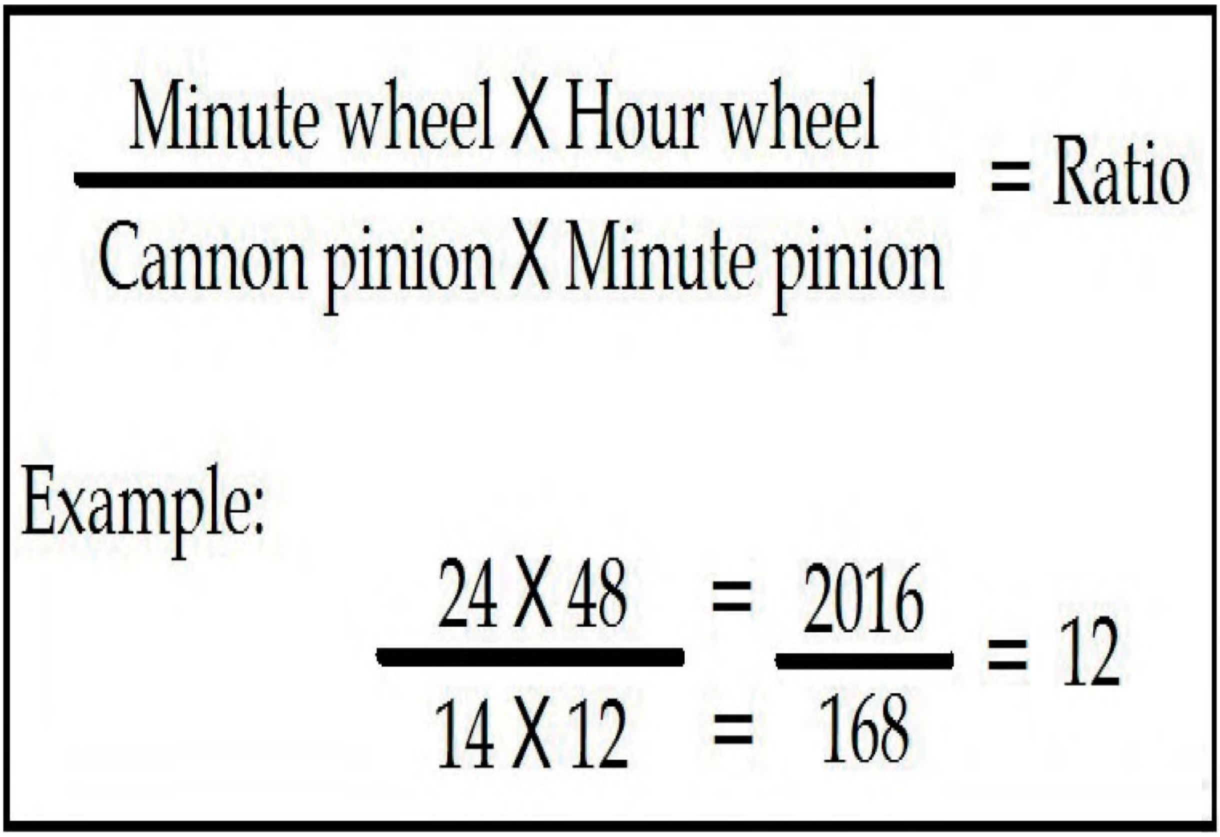


Diagram 6: Motion work. 1 Minute hand; 2 Hour hand.

The cannon pinion (red) turns three times to rotate the minute wheel (blue) once (42/14 = 3), while the minute-wheel pinion (green) turns four times to rotate the hour wheel (yellow) once (48/12 = 4).

To work out the ratio, use the equation in the diagram below. You may possibly be thinking, why do you need to know? You may decide (in the future) to make a watch, or you may be given a watch with a missing hour/minute wheel that you are unable to obtain. The only real solution to this would be to make the wheel or find a wheel from a similar watch, and you would need to know the exact number of teeth on that wheel.

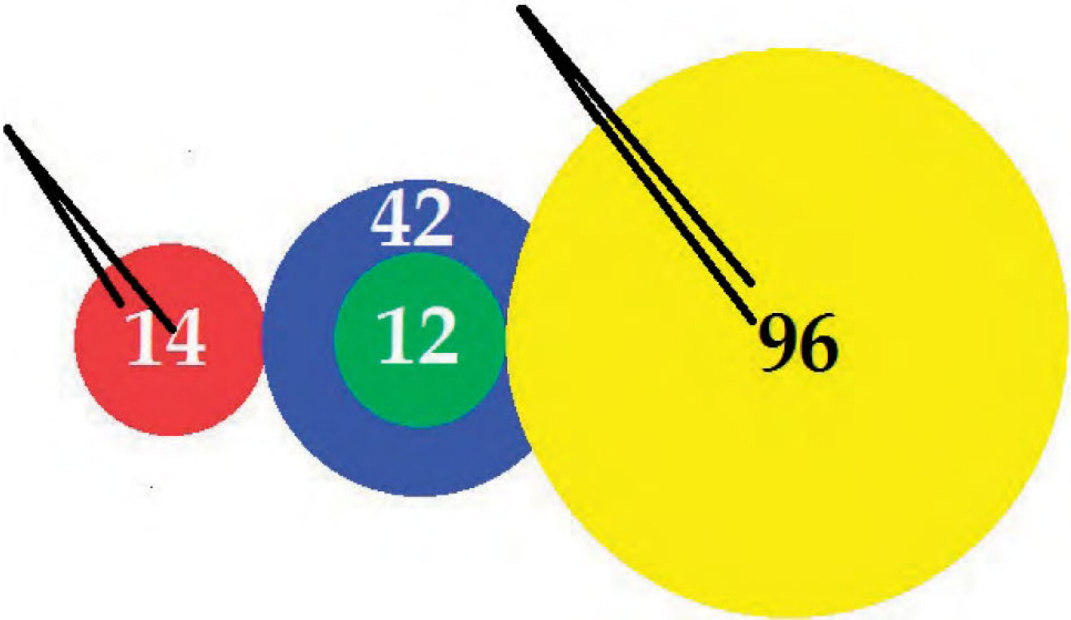


$$\frac{\text{Minute wheel X Hour wheel}}{\text{Cannon pinion X Minute pinion}} = \text{Ratio}$$

Example:

$$\frac{24 \text{ X } 48}{14 \text{ X } 12} = \frac{2016}{168} = 12$$

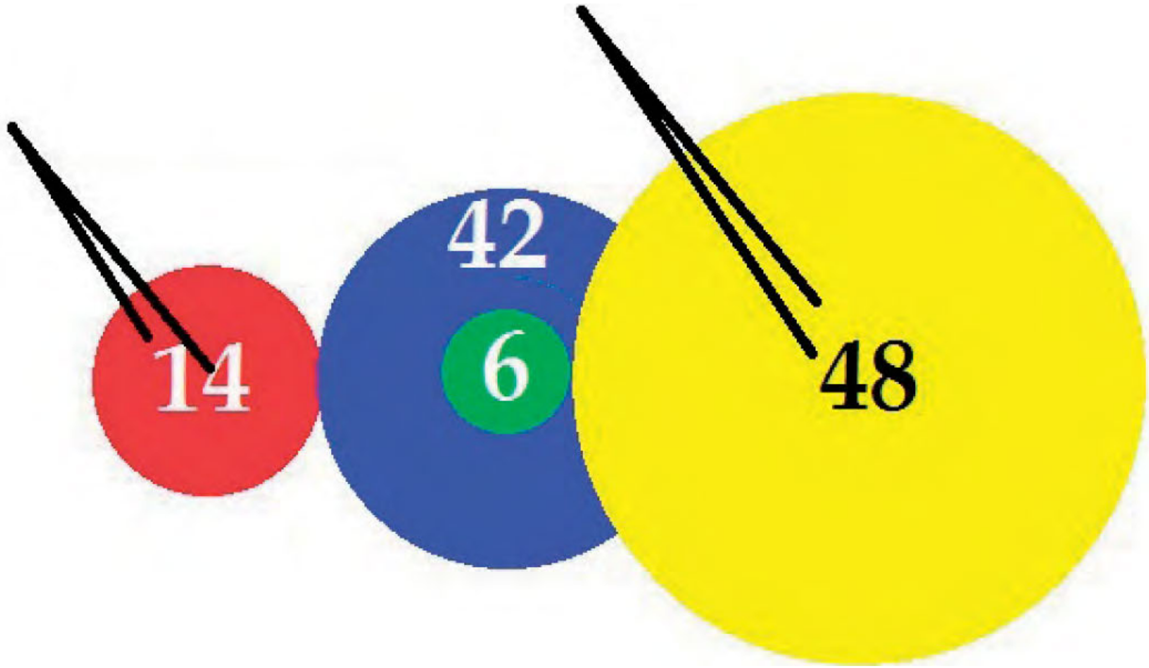
Diagram 7: Calculating the ratio.



$$\frac{42 \text{ X } 96}{14 \text{ X } 12} \begin{matrix} = \\ = \end{matrix} \frac{4032}{168} = 24$$

Diagram 8: Motion work.

Diagram 9: Motion work.



$$\frac{42 \text{ X } 48}{14 \text{ X } 6} = \frac{2016}{84} = 24$$

Diagram 10: Motion work ratio.

Diagram 11: Worked example of the motion work equation.

It will also help you realize that the numbers of teeth in a watch are not just random numbers.

If we have a watch that needed a twenty-four-hour dial we could double the number of teeth on the hour wheel, or halve the number of teeth on the minute-wheel pinion: see the equations in the accompanying diagrams.

However, you might notice that there is something unusual about these pictures. We have already seen that the minute hand sits on the cannon pinion (red) and the hour hand sits on the hour wheel (yellow)… so this would give us an odd dial layout. But this is not as odd as you might think, because this style of dial layout was very popular with box chronometers (a ship's timepiece of very high quality, used for navigation), and also with observatories for use in star gazing. It has also been used by manufacturers who wanted to have a watch with an unusual dial layout (for examples of clocks with an unusual dial layout, I would recommend researching Harrison).

14. KEYLESS WORK

To understand what is meant by the term ‘keyless work’ it is important to be aware that watches have evolved from clocks. Mechanical clocks and watches need winding on a weekly or daily basis, and early watches were wound with a key, just the same as clocks.

KEY-WOUND WATCHES

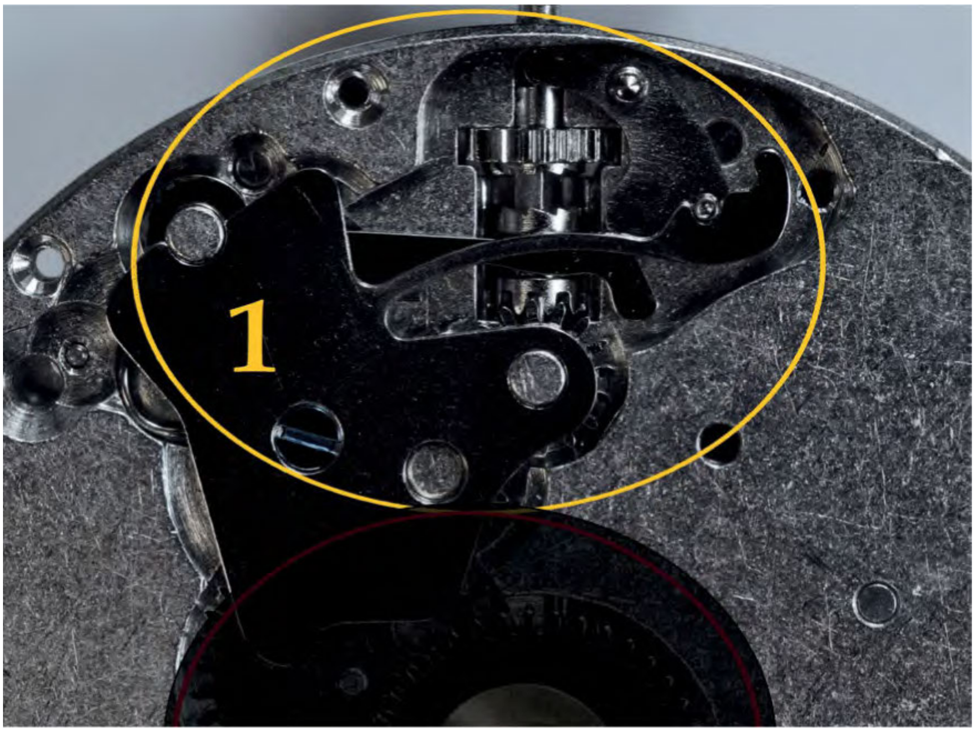


Fig. 82: The modern Swiss keyless work shown in the hand set position (the button is pulled out to set the hands).

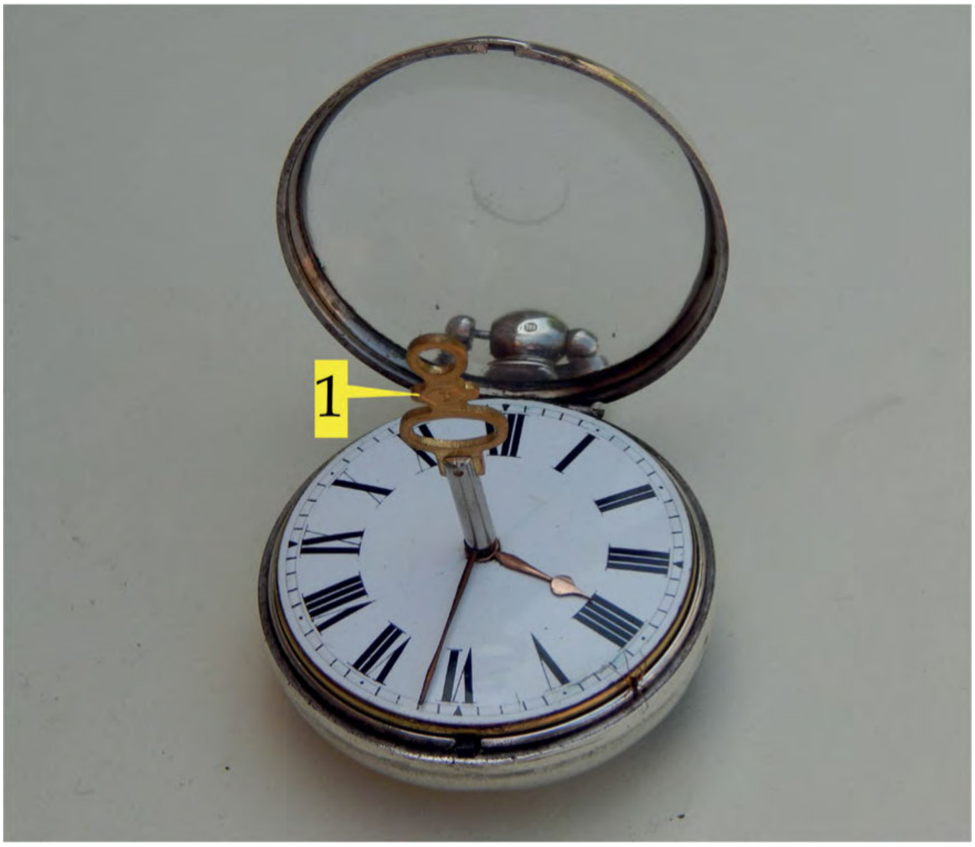


Fig. 83: An eighteenth-century watch that requires a key (image 1) to set the time. This is done by fixing the key to a square on the end of the cannon pinion. The watch is wound from the back through a hole in the back of the case. This is a pair case watch.

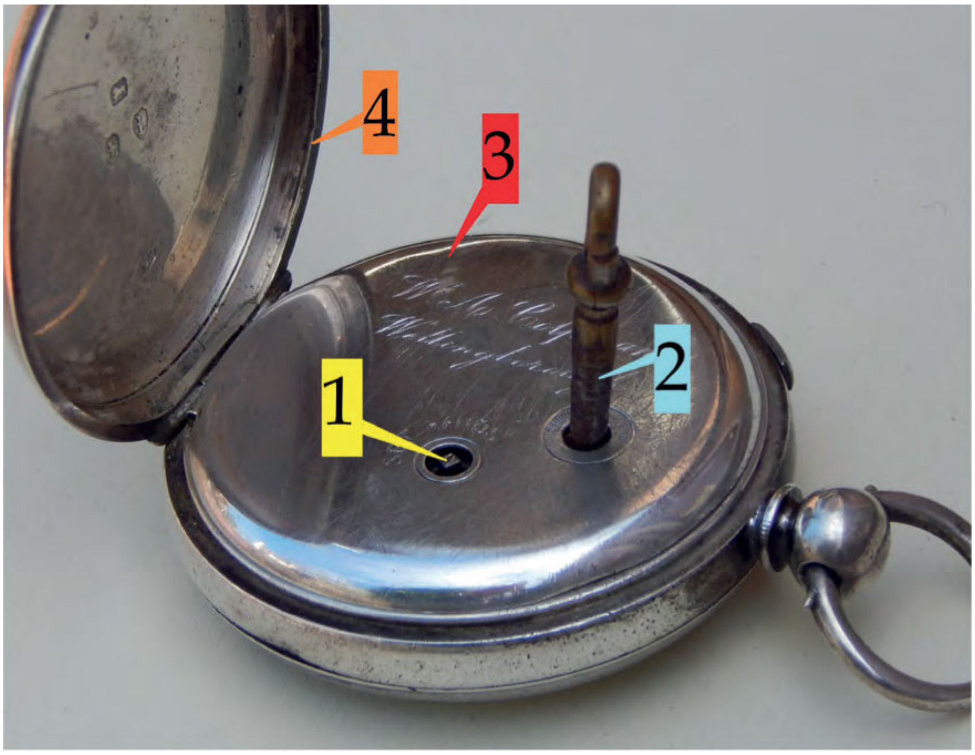


Fig. 84: A nineteenth-century watch. The time setting (1) and winding (2) are achieved through holes in the dust cover (3) using a key (2). (4) The case back.

With the earliest pocket watches you would open the front-hinged glazed bezel that protects the dial. A key would fit into a hole on the top of a square on the cannon pinion just above the minute hand, and you would turn the key to move the hands. You might think it would be easier to push them with your finger, and this would be almost all right with a watch that had quite thick, rugged hands. However, this type of hand is never very pretty, so most early pocket watches have quite delicate hands, and if you pushed this type with your fingers they would not withstand the pressure, and would just snap off.

To wind this type of watch you would use the same key on a second square with a hole in the dial, or in the back of the case.

This type of watch soon fell out of favour, as a careless owner would quickly damage it as they poked the key at the dial whilst trying to wind it, chipping its face in the process. Also, the temptation to push the hands with the fingers often became too much and they ended up breaking them off.

Watchmakers soon opted for a rear wind, still using a key, but instead of opening the front of the watch, there was a hinged lid on the back of the watch, revealing a second cover. In this cover were two holes with two steel squares protruding from the movement. You would set the hands to the desired time with a key fitted into the hole in the centre square, and wind the main spring using the second square shaft. But as watches evolved, watchmakers looked at ways of dispensing with the key, as opening and closing the case would allow dust and skin particles to get inside the case, thereby contaminating the movement and ultimately hindering its reliability. Furthermore lost keys were always a nuisance to the watch owner.

In some cases the key was nearly as big as the watch. Watches evolve, like any technology, and they became smaller. Fashions dictated that occasionally ‘small is beautiful’, and what better way of a watchmaker showing his worth than with a teeny, tiny watch?Today it is hard to imagine tiny watches being fashionable, as many of the watches worn nowadays are as big as some of the last pocket watches in the 1920s. And once watches reached a certain size, watchmakers also started to add a stopwatch or maybe a calendar or moon phase – so you can see where complicated watches come into the story.

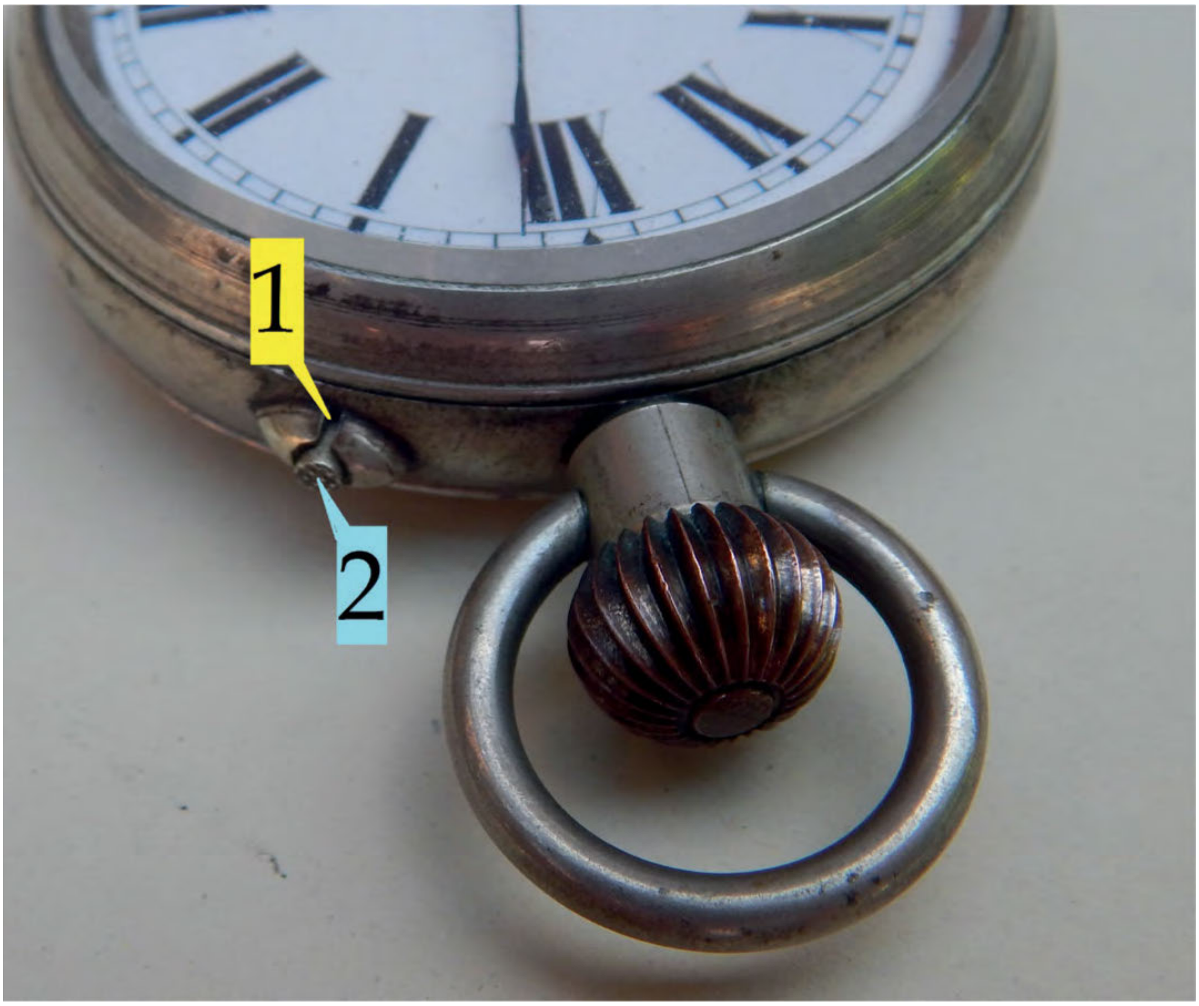


Fig. 85: An early twentieth-century watch with a pin-set keyless work. The watch is wound by turning the winding crown. The setting of the hands is achieved by depressing the pin (2) below the pin guard (1), simultaneously turning the winding crown in the desired direction to set the time.

There have been many different ways of winding a watch without the need of a key or opening the case, but they all had to perform two separate functions: to wind the main spring, and to set the hands to the right time via the motion work. Occasionally the keyless work has to operate a third function, in the form of a fast date change on a calendar watch. However, I will concentrate on the more basic and common type of keyless work fitted to modern wristwatches, as any more may confuse the basic function for you.

An early type of keyless work is the pin set, where a pin is pressed on the side of the case: this changes the gears inside the watch, allowing for hand setting. This style of hand setting is very common with pocket watches, and is explained in detail later, near the end of this book. For now I will concentrate on the most common type of keyless work found in modern watches.

MODERN SWISS KEYLESS WORK

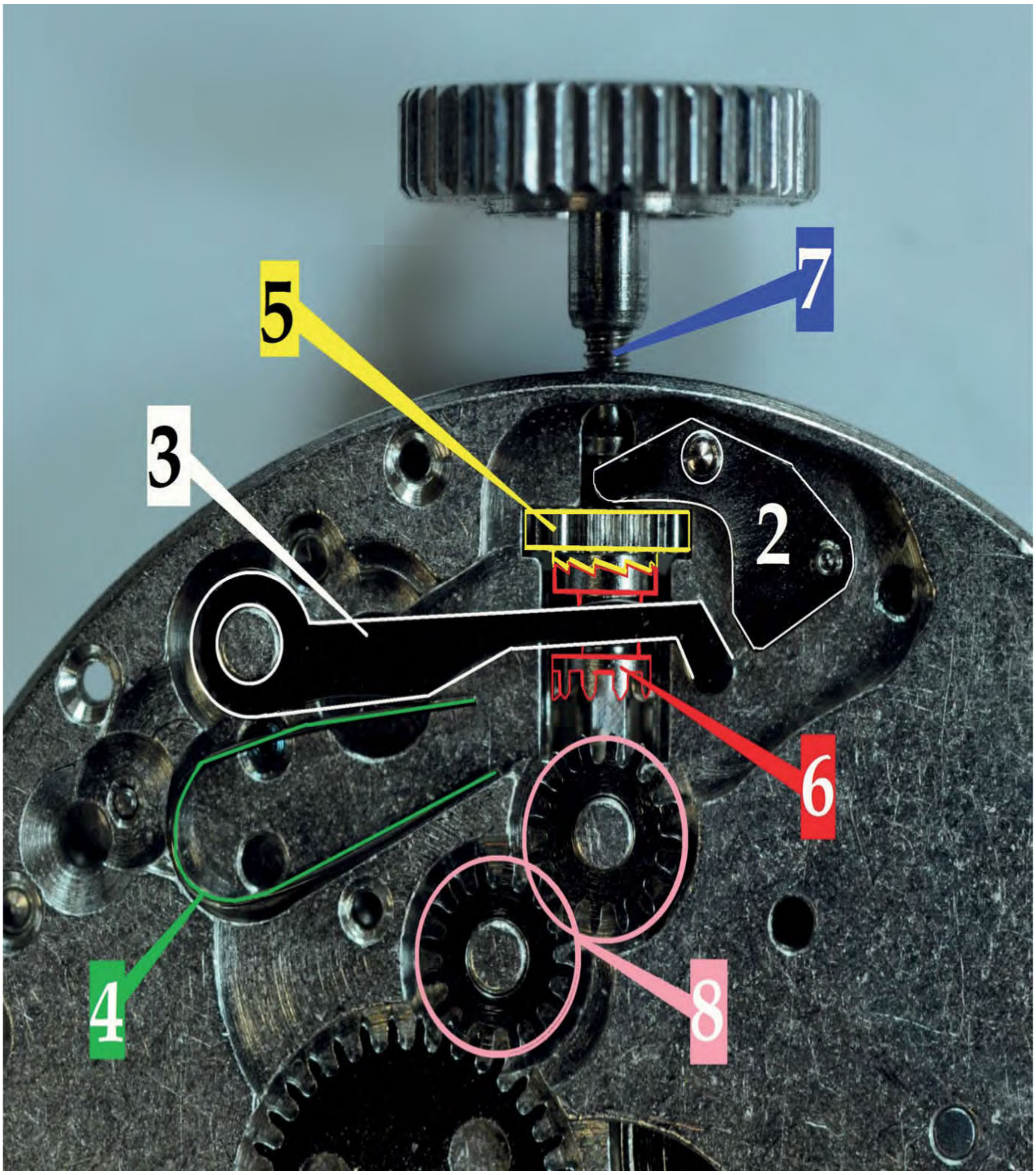


Fig. 86: Modern Swiss keyless work in the winding position: 1: bolt spring (removed). 2: bolt piece. 3: return bar. 4: return bar spring. 5: winding pinion. 6: sliding clutch. 7: stem and crown (winding button). 8: intermediate setting wheels.

All individual watch parts can have three different names to describe the same part, derived from English, French and German. All are correct and all are recognized by the trade. To make it even more confusing, each manufacturer has their own part numbers for each piece. I will try to clarify this by giving you the most common names, and I will use the ones I prefer as typically descriptive of their function.

Refitting the Winding Stem

First, refit the winding stem and its button (crown) in the movement, remembering to tighten the bolt screw on the opposite side. If the winding stem fails to refit, this is due to the clutch misaligning. Don't panic! Read on, as you will be removing all the keyless work shortly.

Tip: When fitting the winding stem and button, rotate the winding stem anticlockwise as it enters the movement, as this will help the gears inside line up, causing the stem to locate inside them.

The reason for refitting the winding stem is so you can wind and set the watch, and also so you can observe the functions of the keyless work. Once you have reached an understanding of how this works you will be able to remove it and reassemble it at ease. My tutor at college maintained that you have to think like a designer. After a watch has been totally taken to pieces, in order to reassemble it, you need to understand how each function works. With this designer analogy in your mind you will have to think, 'How would I go about making the hand set work out of these components?' Trust me, this works.

Whenever I have worked on a complicated watch that I have never worked on before (normally once a year), or when I have carelessly forgotten to take pictures of the movement during disassembly (normally because my phone is out of battery), I have been left with the scary task of figuring out how the watch goes back together. However, it really comes down to simple logic and deduction. You will soon recognize key components, as all watches use the same basic principles in design. You will instantly recognize these, and can use these pieces as your foundations for rebuilding the watch. You will soon realize that you might need something to move this part, to ultimately operate part B and C, and so on.

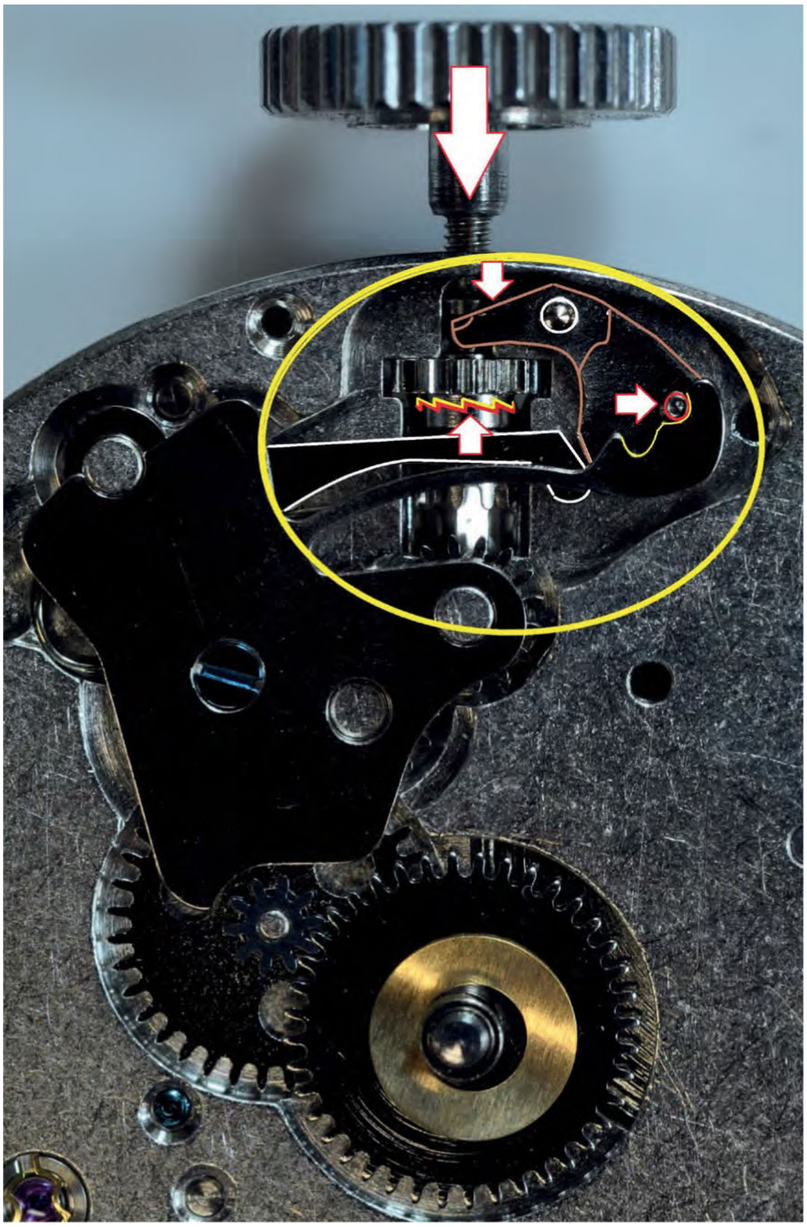


Fig. 87: The bolt piece (looking like a dog), and the return bar highlighted as a leg.

This may seem far-fetched, but believe me I have not yet come across a watch I have been unable to put back together using these steps. As with all of my students, I would recommend taking pictures at every stage, particularly if you ever work on a watch that you are unfamiliar with, and you have no one to help you out. (That said, I would hope my instructions were clear enough to guide you through at this stage, and that you would not find it overly necessary to take pictures. It is also a useful exercise to work without taking pictures on the basic watches in this book.)

Now wind the watch, holding it in your hand, and remembering to be conscious of keeping your fingers away from the balance wheel.

The Sliding Clutch and the Winding Pinion

Look at the front of the movement (where the dial was), and in particular the area where the stem enters the movement, and you will instantly notice a steel gear rotating. This is in fact two separate components rotating as one: the sliding clutch and the winding pinion. To appreciate that they are two separate components, just turn the stem in the opposite direction and you will see the clutch wheel ride over the teeth of the winding pinion.

Look more closely at the sliding clutch, and you should notice it has a lever that crosses over its waisted section, which travels with it when the crown is rotated in the opposite direction. When you remove the sliding clutch later on, you will see that it has saw-shaped teeth on the top, and it looks like a castle keep with its battlements on the bottom. It also has a groove in its middle, somewhat similar to the middle of the cannon pinion that we looked at earlier.

Looking at this part in the movement, you should also notice that a bar/lever passes across this waisted middle: this lever is called the return bar.

The other gear above the sliding clutch that is closest to the winding button is the winding pinion. They should currently be locked together, and they rotate as one. These two gears have mating saw-shaped teeth that are angled so that, during winding, they lock together. However, if you rotate the crown in the opposite direction you will notice that the two gears repel each other, causing the sliding clutch to ride over the winding pinion, while the winding pinion remains stationary.

To understand what is going on, you will need to remove the stem. This time, have a good look at the stem itself. You should first notice that the stem has a square section. This part of the stem slides though the centre of the winding pinion and then through the sliding clutch, which has a mating square. When the stem is rotated, the clutch rotates with the stem. The winding stem does not drive the winding pinion, as this gear has a round hole and is only driven by the sliding clutch. The winding pinion is only driven when the sliding clutch's saw teeth are engaged and turned in the appropriate direction and are locked together. If you look at the stem just above the square, slightly in the direction of the button, you will see a small, round, polished step section. This is where the winding pinion rotates, and it acts as a bearing, nothing more.

You may be thinking, ‘What is actually happening when I turn the crown in the opposite direction to make the sliding clutch wheel ride over the teeth?’ If you turn the watch over to look at the back and wind the watch, you will see two large steel gears rotating. These are ultimately winding the spring. Again, turn the crown in the opposite direction and what do you see?

Nothing at all, so what’s the point of this function? In fact it works like a ratchet spanner used for cars, and is merely an aid to help the owner of the watch wind in one direction.

The Movement of the Sliding Clutch

Turn the watch back over to the front again and let’s look at this movement of the sliding clutch. First, the lever that crosses the sliding clutch is known as the return bar, or yoke. Take a piece of peg wood and sharpen it like a spear, andon the winding stem. Now you can clearly see that the sliding clutch slides up and down on the square of the stem.

If you let go of the return bar it will automatically re-engage with the winding pinion. This is because the return bar has a spring that pushes it upwards to mate with the winding pinion.

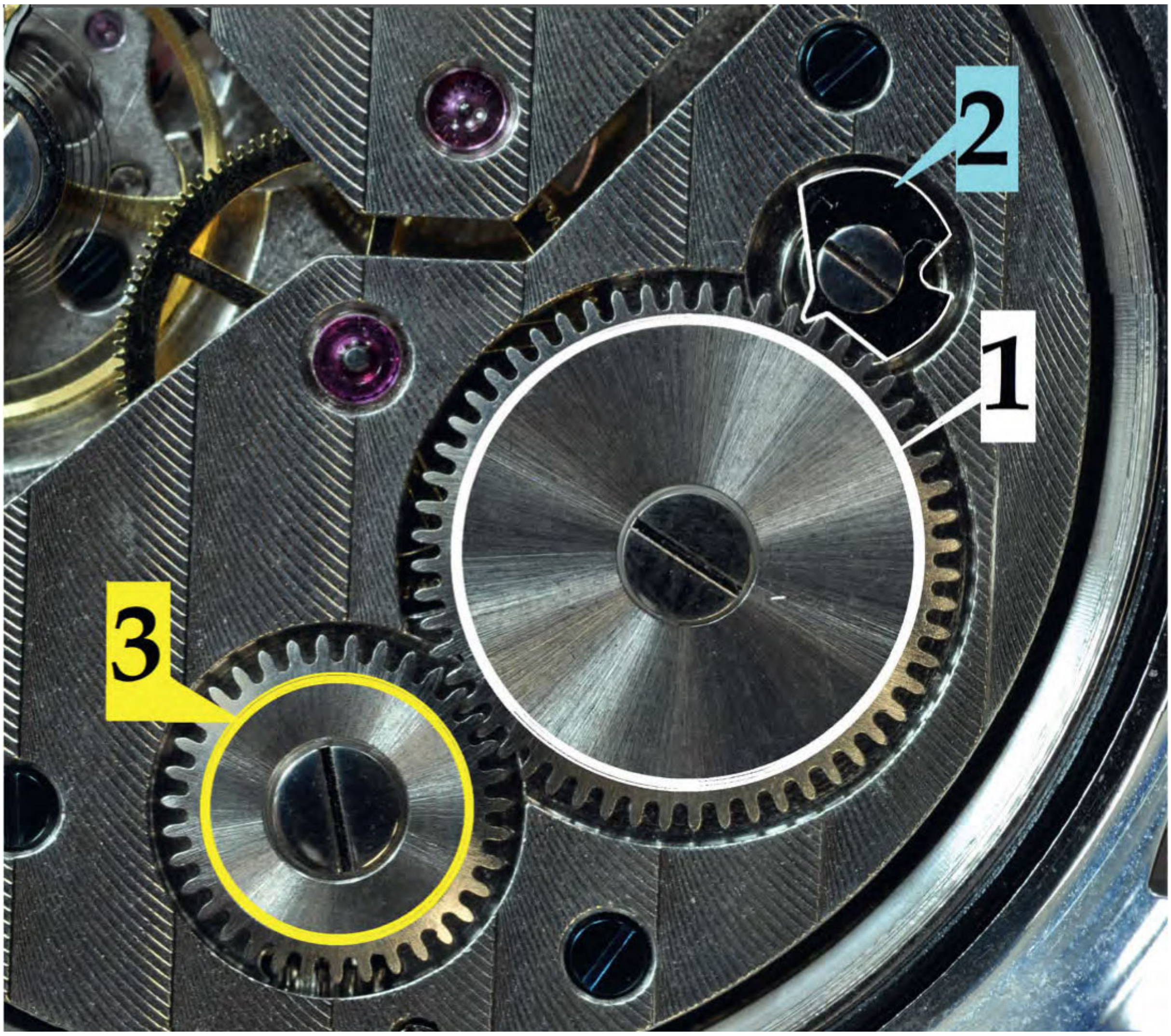


Fig. 88: 1: ratchet wheel. 2: click. 3: upper crown wheel.

The Upper Crown Wheel

Let's go back to the two large gears on the back of the watch. When winding the watch, when you looked at the front you saw the pinion and sliding clutch lock together and rotate as one. Now that the winding pinion is rotating, if you look at the other side of the watch you will now notice that there are two gears rotating, as you have seen earlier. The smaller of the two larger gears is the upper crown wheel, and this wheel mates with the winding pinion at a right angle, changing the direction of motion (similar to the gears on an old-fashioned hand drill).

This wheel rotates on a bearing at its centre; it is held captive by its screw but is free to rotate: the screw only holds it captive, and does not act as a brake in any way. This screw has a left-handed thread, which is necessary because this wheel rotates anticlockwise and a conventional screw would undo as the upper crown wheel tries to lift upwards. A screw that tightens up in the same direction as the wheel turns, keeps it from working loose. This is generally the only left-handed threaded screw you will find in most watches. The only exception is in calendar watches, where you may find one on the calendar change wheel. If left-handed screws are used, some nice manufacturers cut two extra slots in the screw on the screw head at opposite sides of the central slot.

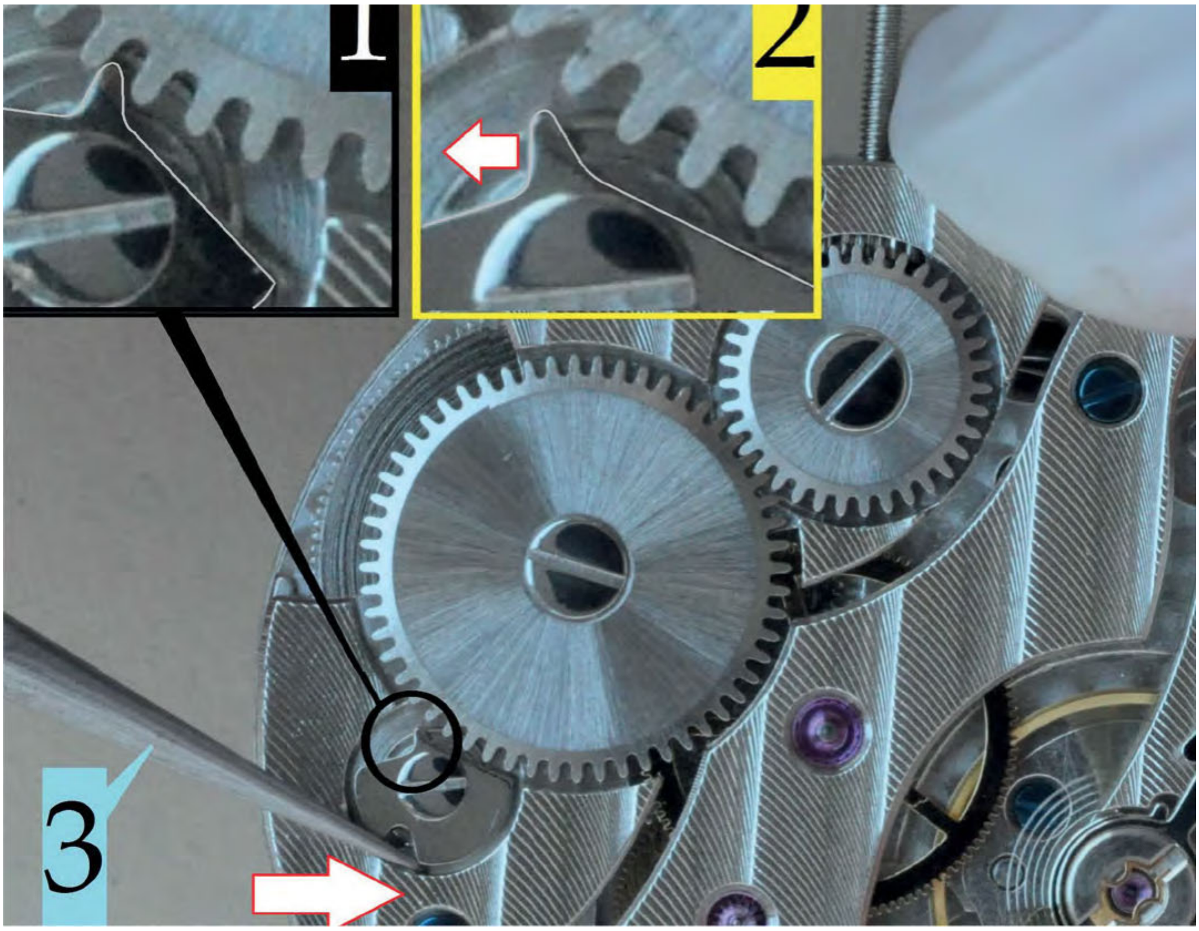


Fig. 89: Image 1: the position of the click before it can be pulled back with the tweezers (3). Image 2: the click pulled back to enable the spring to be let off.

The Ratchet Wheel and the ‘Click’

The second larger gear is the ratchet wheel. This gear has a square hole at its centre (not currently visible and covered by a large screw). This square mates with a square shaft on the end of the barrel arbor, and the ratchet wheel is fixed to this arbor by a screw. Connected to the barrel arbor is a ribbon of springy steel called the mainspring, and as the arbor turns, it winds the spring inside the barrel.

If we focus on the ratchet again and wind the watch, you will see a little disc with a screw at its centre. This disc moves over the top of each individual tooth, moving up and down like a nodding dog allowing one tooth at a time to pass, preventing the ratchet wheel from rotating backwards and allowing the spring to unwind. This is called the ‘click’ (named for the noise it makes during winding). It allows the ratchet wheel to turn in one direction only, and also acts as a brake, preventing the spring from unwinding, which would allow the energy being stored to be lost. This is a similar device found in a hand brake in a car, which stops your car from rolling down a hill: you pull the handle up (click, click, click).

Place the watch movement in a movement holder with the ratchet wheel facing you, and being mindful of the balance wheel. Take the piece of peg wood that you used earlier, and rotate the winding crown with your free hand, turning it very slowly. When you see the click just about to ride over a tooth of the ratchet wheel, stop turning the winder and hold it there. Now, with the peg wood in your other hand, rotate the click upwards (lifting the dog’s head upwards) away from the ratchet wheel and hold it there.

Very slowly, loosen your grip very slightly on the winder, allowing the crown to rotate between your fingertips. You should also see the ratchet and crown wheel rotating in the opposite direction from winding. This is caused by the energy stored in the main spring releasing or unwinding: we call this ‘letting down the power’.

A severe word of warning at this point: if you loosen your grip too quickly on the winder, the energy will be released too quickly and will result in damaging the spring. (This will cost you the equivalent of a bottle of wine, and I know which one I would rather have.) We will look at the main spring later on, in the chapter that covers energy storage.

SETTING THE HANDS

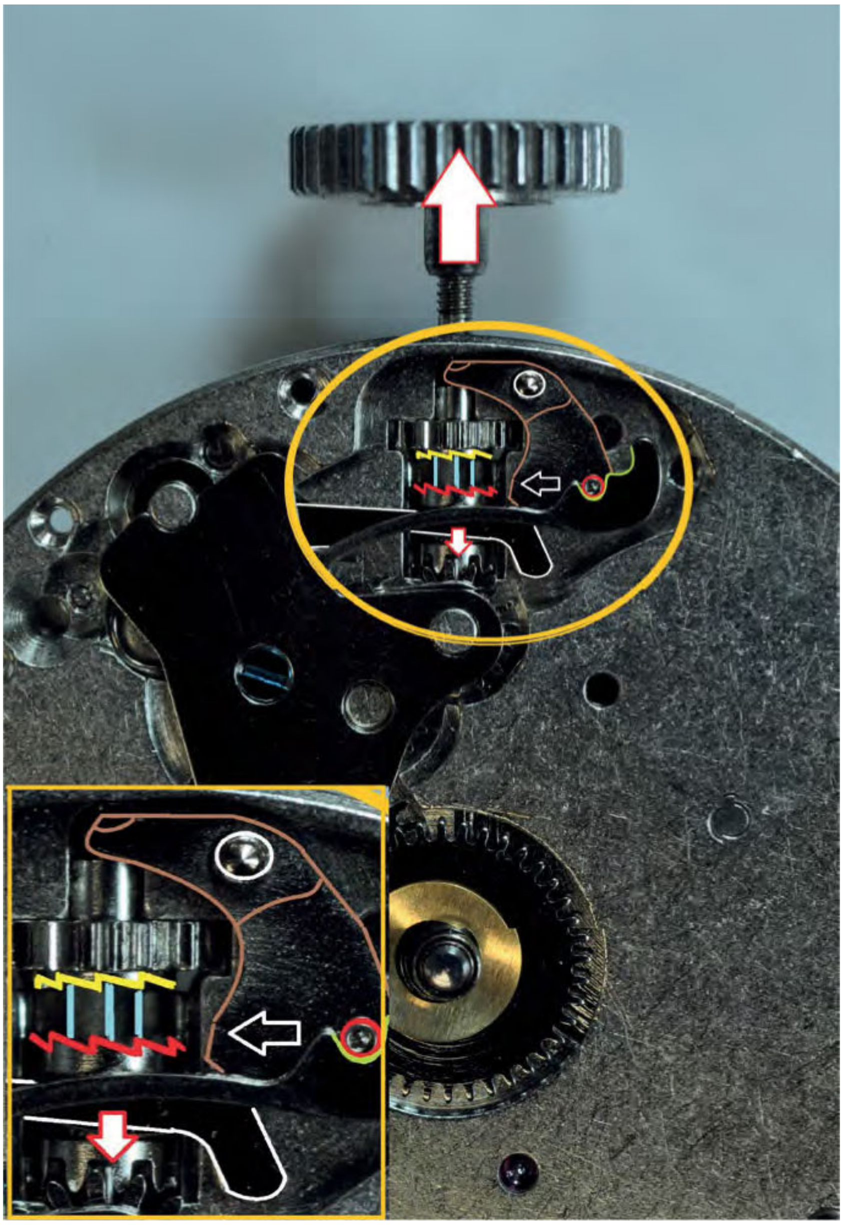


Fig. 90: The bolt piece (looking like a dog) and the return bar (highlighted as a leg). The keyless work is in the hand setting position.

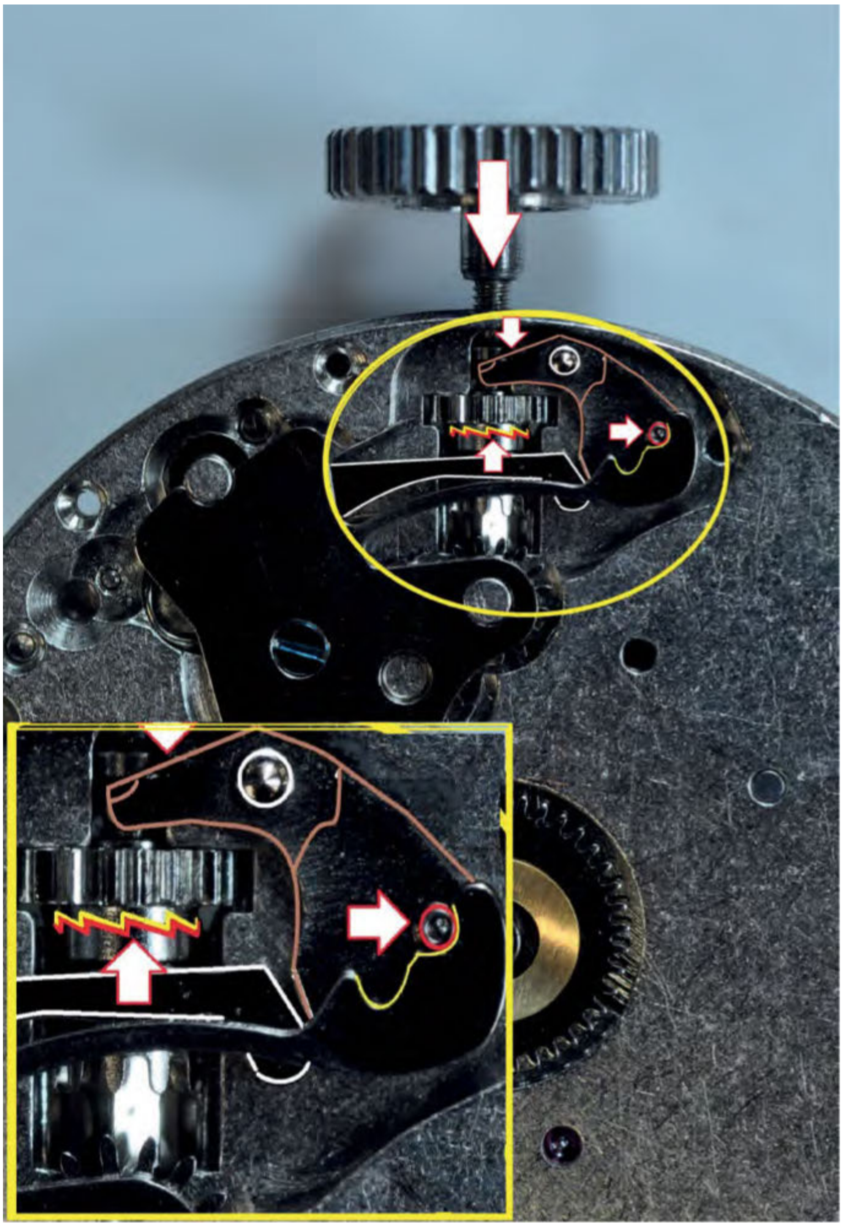


Fig. 91: The bolt piece (looking like a dog) and the return bar (highlighted as a leg). The keyless work is in the winding position.

Remove the movement from the movement holder and place it on its back to look at the keyless work again. Pull on the crown to engage the watch into hand set. If you look closely you will see a little lever shaped like a King Charles spaniel, called the bolt piece. As you pull on the stem this bolt piece will rotate on what looks like the eye of the 'spaniel'. It will lift its nose in the air as you pull on the winding stem. The bolt piece has a finger piece on the nose end of the 'spaniel' that is on the underside of the bolt piece which engages in the waisted part of the stem that you may have noticed earlier on. The stem pulls on the bolt piece, making it rotate on its shoulder screw (the eye of the ‘spaniel’).

If you look at the bolt piece around what would be the long ears of the ‘spaniel’, you will see that there is a pin protruding upwards. On this pin, the bolt spring (cover plate) presses down, helping to keep the keyless work locked in hand set or in winding mode. As the bolt piece rotates (or the ‘spaniel’ puts its nose in the air) it rides over the bolt spring, moving from one notch to another.

At the same time the very tip of the dog ear of the bolt piece pushes on the foot of the return bar. As the return bar is pushed downwards it takes the sliding clutch wheel with it. As the clutch is made to slide on the winding stem, it disengages with the winding pinion and moves towards a small steel pinion called the setting pinion.

The bolt piece locks into the next notch on the bolt spring, the keyless work is now locked in hand set.

Now, if the stem is rotated, the clutch will rotate as one with the stem, thus turning the intermediate setting pinion and other gears to turn the hands. The winding pinion remains stationary as it can only rotate when it is engaged with the sliding pinion, due to its round hole.

15. REMOVING AND REFITTING THE KEYLESS WORK

To remove the keyless work you will need the following tools: a large, clear, resealable bag about 15 x 10cm in size, and No. 2 tweezers or their equivalent.

Place the movement on the bench with the keyless work facing you. Make sure you are not working on the edge of the bench, because if you drop a part or flick it out of your tweezers, it will land on the floor, and as mentioned earlier, it is much easier to recover a part from your bench than the floor. Check that the watch isn't in hand set, but is in winding mode.

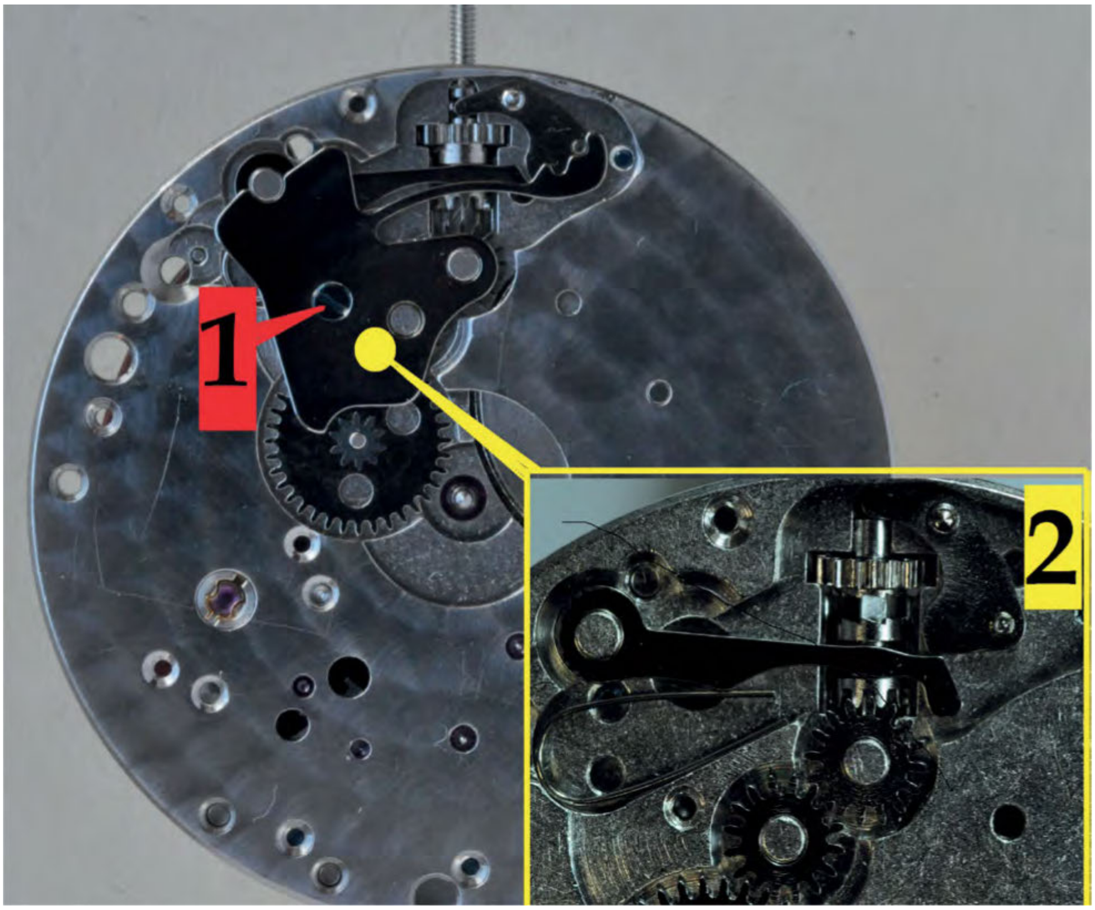


Fig. 92: Remove the cover plate screw (1). Remove the cover plate (2).

Undo the screw that is holding the cover plate in place (see Fig. 92), using a suitable screwdriver. Place the movement inside the re-sealable bag and carefully seal it closed. (If you can't find a bag, then cling film will do, but make sure that you use a large enough piece to cover the whole movement, as there is a much higher chance of the spring escaping using this method.) With your tweezers, poke through the plastic or cling film and lift off the bolt spring. We use a bag because we will next be removing the return bar spring, and these are lively little chaps, often making a leap for freedom, normally over your head and into space, never to be seen again.

Tip: If you look where the return bar is pivoted and where the return bar spring just touches it, there is a little gap where you can grab the spring with your tweezers and pull it out. Don't be tempted to pull the spring out through the side opening of the bag, as it will try and escape, similar to that spider you tried to catch under a coffee cup.

Once you have removed the spring, carefully remove the movement from the bag and recover any parts that have jumped off the movement, including the cover plate and the return bar spring. Place them all in a container. When you place the cover plate in a pot, make sure that the intermediate setting wheels haven't stuck to it, as they may cause you some panic later on when you can't find them.

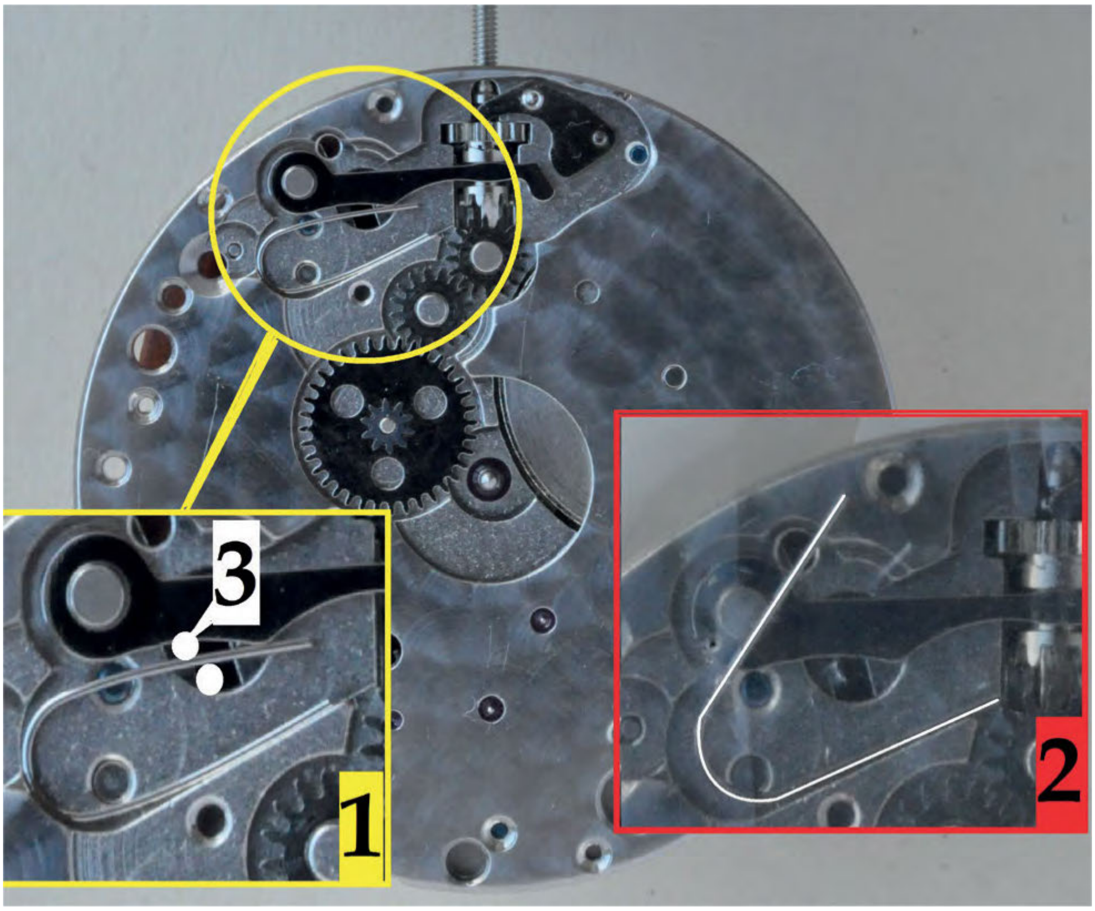


Fig. 93: Remove the return bar spring shown in image 1 using your tweezers (3). This is best undertaken inside a plastic bag (2).

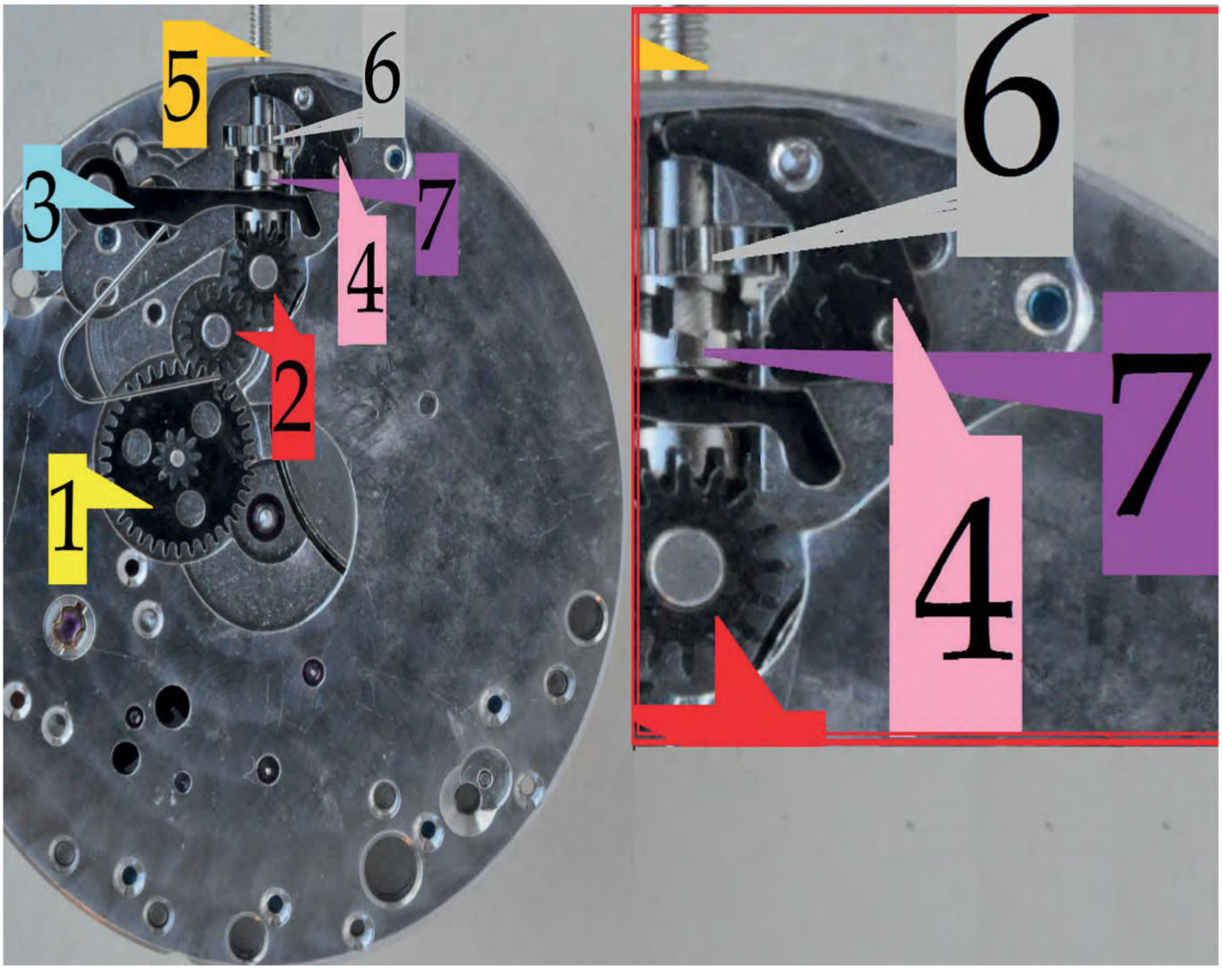


Fig. 94: Remove the parts in number order.

Lift off the following: the return bar (if you have not done so already), the two setting pinions, and the minute wheel. Turn the watch over and undo the bolt screw until the bolt piece falls off. Again, make sure this is not done on the edge of your bench. If the bolt piece manages to escape, the first place I would look is the movement holder, as you quite often find that they try and hide in the screw thread of the holder, or they drop on to one of the jaws, trying to camouflage themselves.

Once the bolt piece is off, you can then lay the movement on its back. Proceed to remove the stem, followed by the winding pinion and the sliding clutch. Once the clutch and winding pinion are removed, you can examine them in more detail. Notice the square hole in the clutch and the round hole in the winding pinion.

Tip: If you have problems lifting out the setting pinions and the return bar with your tweezers, you can use a piece of Rodico on a bit of peg wood to lift them out.

REFITTING THE KEYLESS WORK

Place the movement on the bench. Put back the winding pinion (this looks like a crown) and the sliding clutch (it looks like a castle) into the hollow cavity, where the stem passes though. Have a good look at these two parts and make sure you place them the right way round: if you recall, they have matching teeth that lock together, so the sliding clutch can drive the winding pinion when the two gears are engaged in winding mode. The other end of the sliding clutch has regular shaped teeth, similar to the cannon pinion. These teeth engage with the intermediate setting pinion when the watch is in hand set (just like a hand drill).

Refit the stem, passing it through the winding pinion and sliding clutch. If you have fitted these correctly you should be able to slide the clutch up and down on the stem, engaging and disengaging it from the winding pinion. This is your last chance to make sure you have fitted the sliding clutch round the right way.

Refitting the Bolt Piece

Refit the bolt piece (the ‘spaniel’s’ head). On examination, this part should have two raised pips/posts on opposite sides. The first of these is located on the nose of the ‘spaniel’, and this part engages with the stem to make the bolt piece nod like a dog when the hand set is operated. This pip is placed on the underside of the bolt piece, and the second part is on the spaniel’s ear: this side is the top of the bolt piece. Place the hole in the bolt piece (or the eye of the spaniel) on top of the bolt screw that is protruding from the movement (the bolt screw will not have fallen out as it is held captive by the barrel bridge). The screw is placed 2mm to the right of where the stem enters, and 2mm in from the edge of the movement. You will have to balance the bolt piece on top of the screw. Place your finger cot-covered left index finger on top of it. At the same time, pick up the movement and holder with the rest of your finger cot-covered fingers on your left hand. With your right hand, and using a suitable screwdriver, tighten up the bolt screw on the other side of the movement to refit the bolt piece. Take care not to let the stem fall out throughout this process.

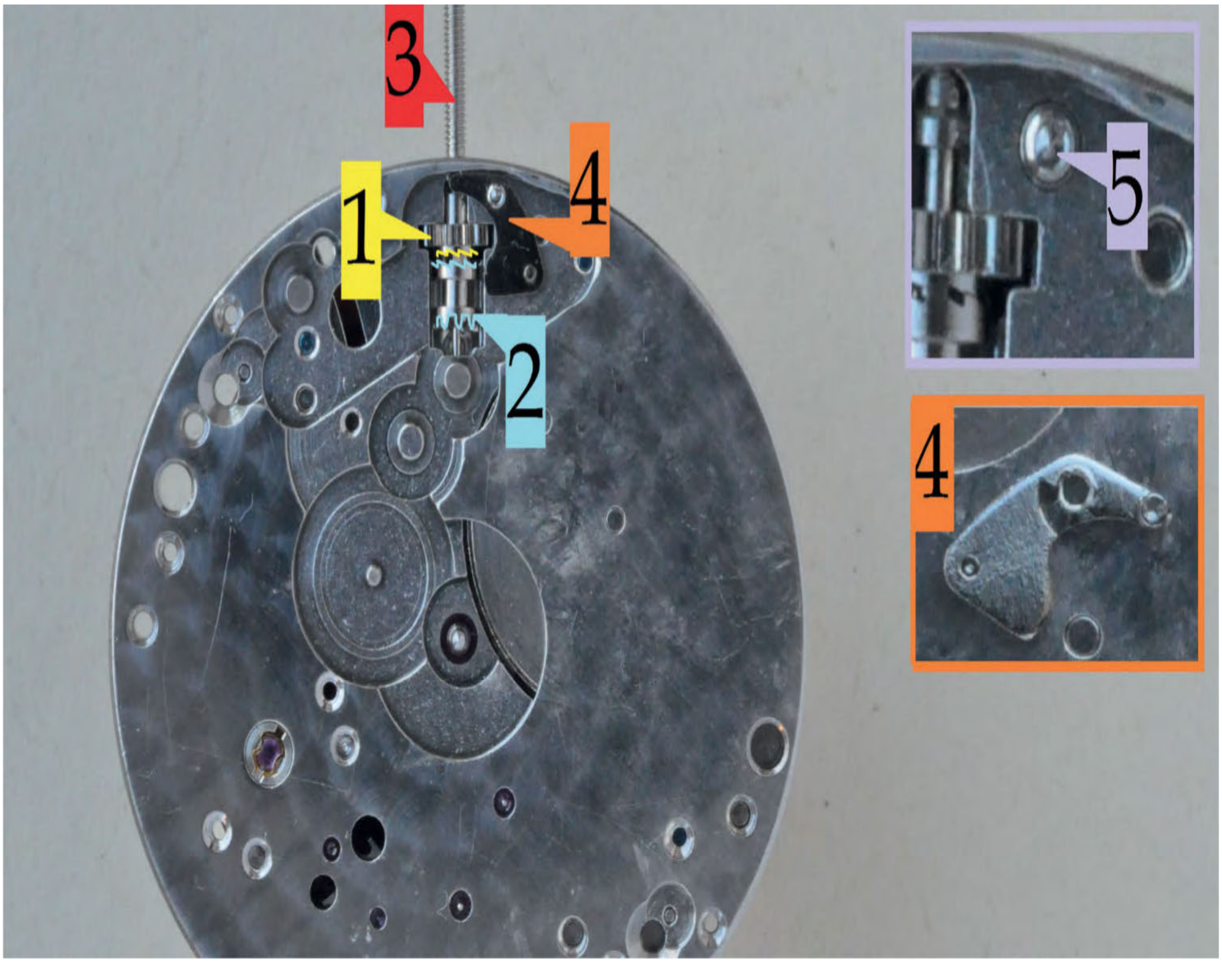


Fig. 95: Replace in the numbered order. Image 5 shows the boltscrew which the bolt screws on to.

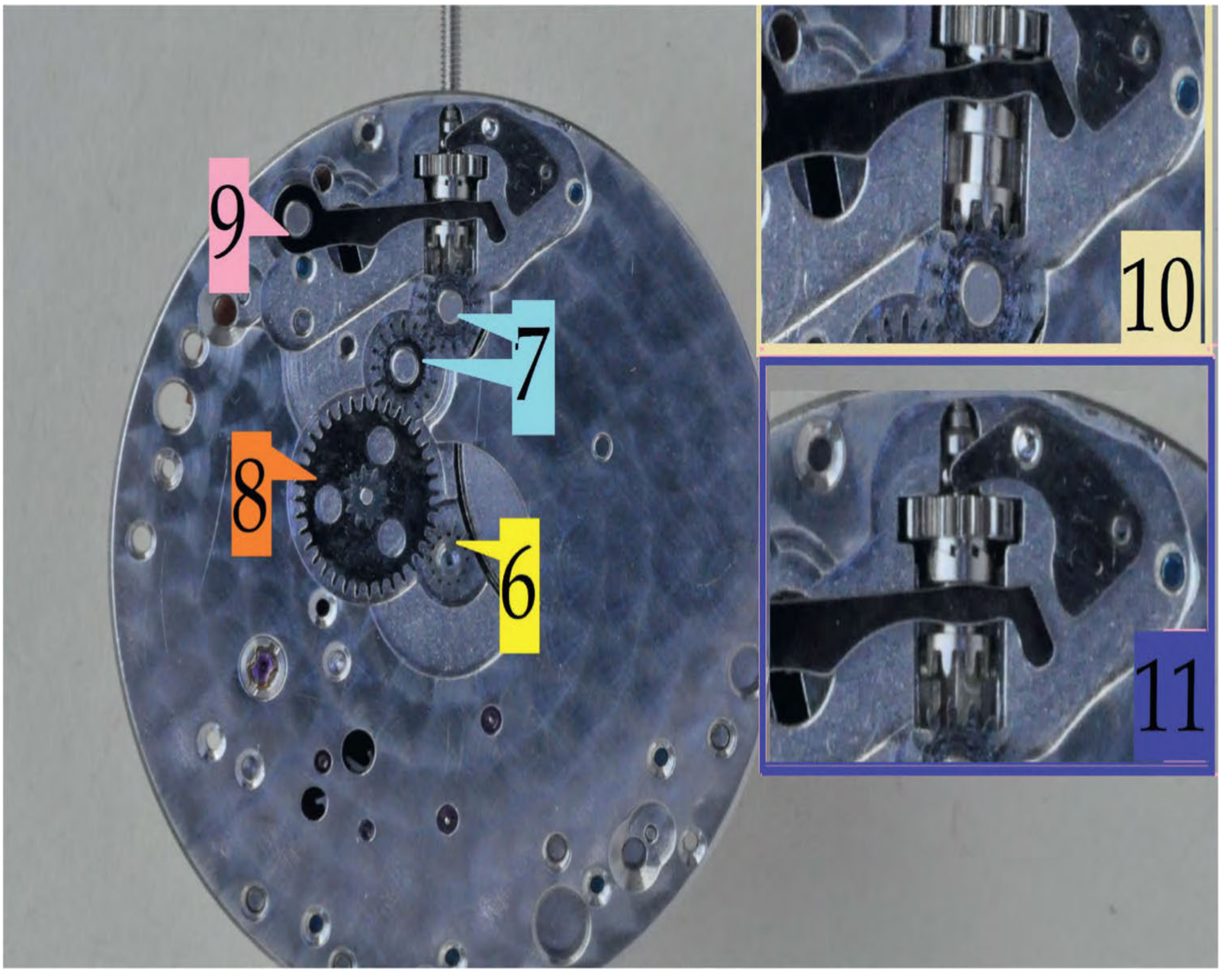


Fig. 96: Replace the components in the numbered order 6, 7, 8, 9. Do not fit the return bar as shown in image 10, in between the winding pinion and sliding clutch. The correct position is shown in image 11.

It will probably take a couple of attempts to refit this part, so let me remind you to do this well over the bench to avoid losing parts. If you have fitted this properly, you can pull on the winding stem and crown and it should not pull out of the movement. If it does pull out, don't panic, just refit the stem and turn the movement over and refit in the holder. Loosen the bolt screw by one complete turn. Push the stem into the movement, and retighten the screw.

Refitting the Cannon Pinion

Once the bolt piece is fitted correctly, the next item to refit is the cannon pinion you removed earlier when reading about motion work. Put the thinner part of the cannon pinion in a pin vice (not the gear end).You only need loosely tighten the pin vice for this job: it needs to just grip the cannon pinion. This will make life easier when it comes to removing the pin vice from the fitted cannon pinion later on. Lay the movement on the bench, not in a holder. This is because the bench will support the centre wheel's pivot.

Caution! If you have a watch with a winding crown larger than the thickness of the movement you will need something like a table coaster or a piece of thick plastic to lift up the movement so that the crown is clear of the bench. When we refit the cannon pinion you end up pushing down on the movement, and without this spacer you will snap the winding stem in two.

With the cannon pinion in the pin vice, slide the whole of the cannon pinion down the shaft of the extended pivot of the centre wheel, as far as it goes. Give the pin vice a good push to lock it in place: you will hear a definite click if you have completed this task properly. If you have the Seagull movement you will need to use quite a bit of force to refit it! (Apparently the same amount that it would take to kill a cockroach with your thumb – I personally have never done this, but I have it on reliable authority that it's a lot.)

Refitting the Intermediate Setting Pinions

Replace the intermediate setting pinions. These will be located on the bottom end of the sliding clutch. They mate with each other and they are both the same size, so it doesn't matter which post they go on.

Fit the minute wheel between the last intermediate setting pinion and the cannon pinion. A lever is needed to operate the sliding clutch, and this fits on the post on the opposite side of the movement to that of the bolt piece; it looks like a prosthetic leg and foot. If you fit this correctly, the toes of the 'foot' should be pointing away from the bolt piece, so that only the heel of the 'foot' engages with the ears of the 'spaniel' bolt piece. This lever should also pass across the centre of the sliding clutch, so that when it moves, so does the sliding clutch.

Refitting the Return Bar

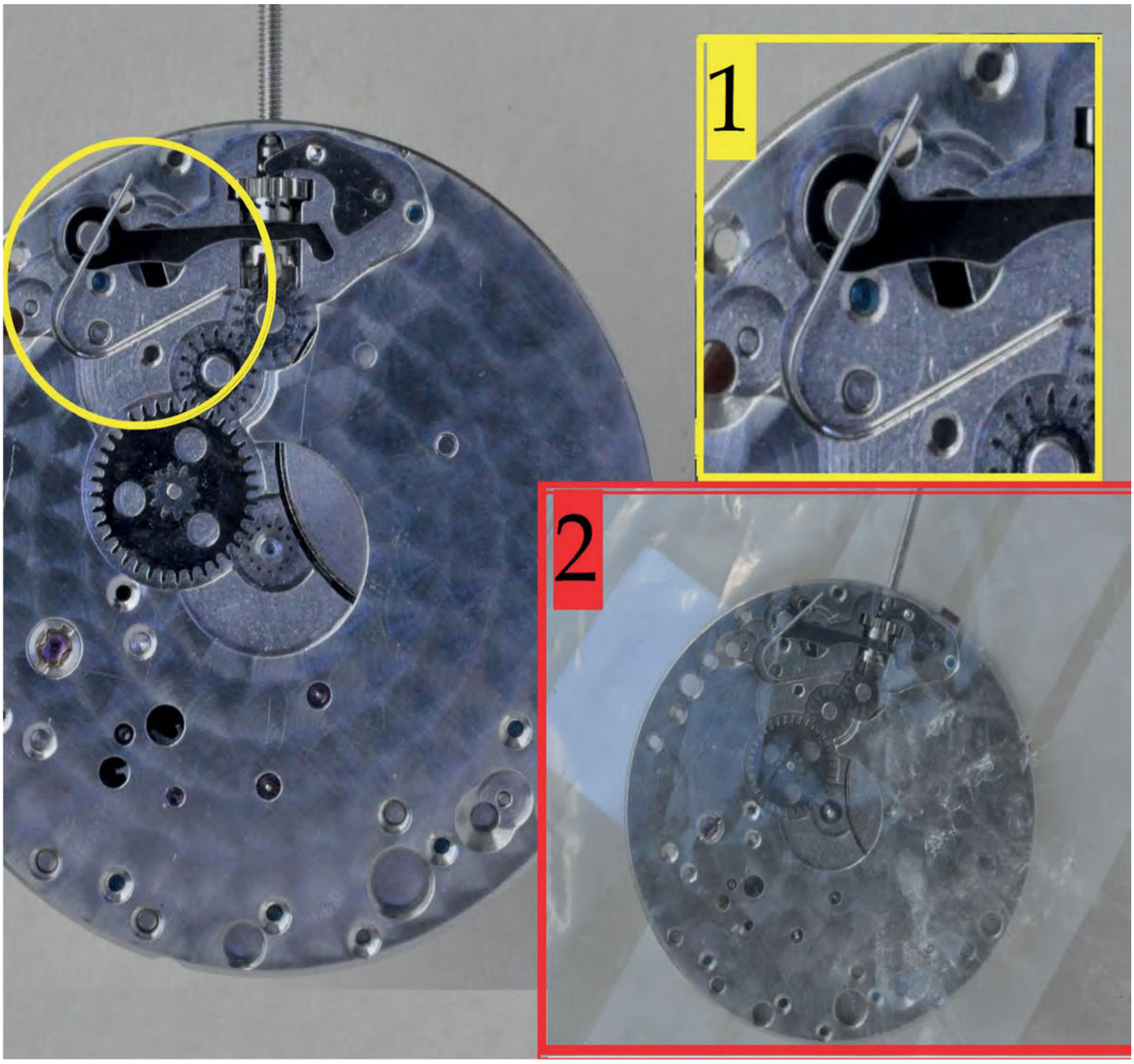


Fig. 97: Refitting the return bar spring. This should be done inside a plastic bag (shown in Image 2). Place the spring in the watch (shown in Image 1). Pull the spring down under the return bar.

To refit the return bar, place the movement back in a holder, and place both in the resealable bag. Through the opening, roughly fit the return bar spring into its cut-out. This is under the pivot point of the return bar, so that the ends of this U-shaped spring are pointing in the direction of the 'ears' of the bolt piece. Fit the spring so that the top part is resting under the return bar, so only the bottom part needs to be compressed to fit its cut-out. Seal the bag closed.

Put your left-hand index finger on top of the return bar, where the spring is resting against it. With your No. 2 tweezers, grab the bottom loose end of the return-bar spring and compress it so that it tucks into the cut-out, whilst keeping your finger on top of the return bar. If you have completed this task properly, the spring should be pushing the return bar up towards the bolt piece. Carefully remove the watch from the bag, taking care not to touch the button as the keyless work will explode.

Fitting the Bolt Spring

Now we need to quickly fit the bolt spring. If you look at this part to try and determine how to fit it, you will see that there is a large semi-circular section cut out of it. This part holds the minute wheel captive and this should give you a rough idea of where to place the bolt spring. On the opposite end of the bolt spring, there is a long waisted piece with two notches cut out of it. This is the spring for the bolt and acts on the pin/pip on the spaniel’s ear.

There is also a smaller semi-circular section, and this hugs around the post of the return bar. There are two holes situated over the two setting wheels. Make sure you have the posts of the setting wheels located in the holes in the bolt spring before you fit the screw. At this point you do not need to be concerned with the spring end of the bolt spring, just tighten up the screw. Once the bolt spring is fixed in place, you need to pull the spring end of the cover plate so that it clips under the pip of the bolt piece. It may have already located in place, and if it has, this is a bonus!

Now, if you turn the winding crown the watch should wind up. Similarly, if you pull out the button for hand set you should be able to set the time. If not, you will have to backtrack and see what you have done wrong, step by step.

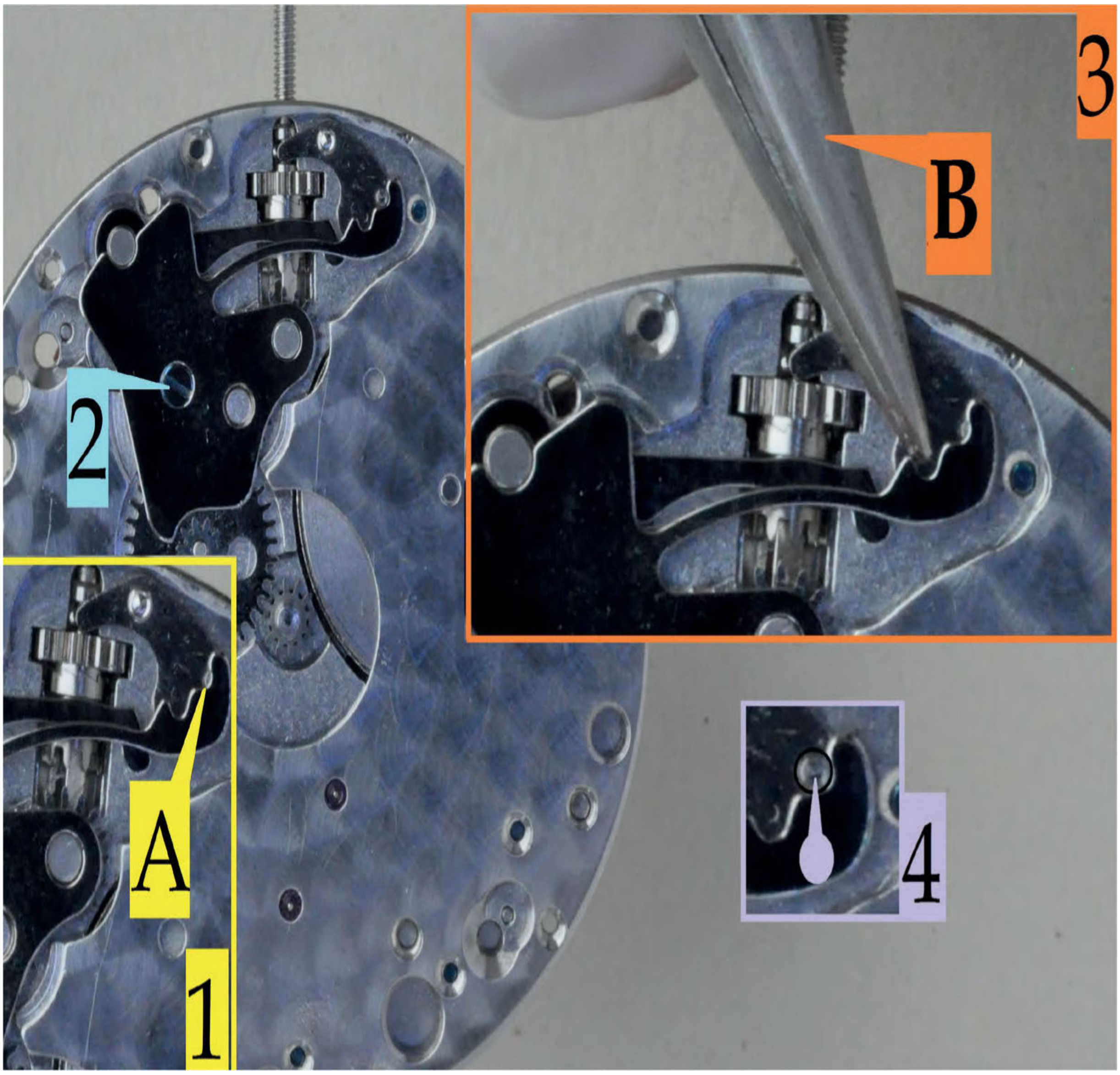


Fig. 98: Refit the cover plate (shown in Image 1). Do not be concerned with locating the bolt spring under the bolt pieces nib (A). Once you have replaced the cover plate screw (2), pull back the bolt spring so that it resides under the bolt piece's nib (shown in Image 3) using your tweezers (B).

16. THE MAINSPRING AND BARREL

When you wind your watch, you are basically bending a piece of springy material, and this energy is then used to drive the watch. This is because the spring is trying to regain its natural shape, caused by the elasticity of the material. Think back to your school days: you must at some stage have twanged a plastic (or possibly wooden) ruler on the edge of your desk. What you were actually doing (other than annoying the teacher) was bending a spring, storing energy inside it, and then releasing this energy. The ruler was bent, and after making its noise, regained its shape. This is the elasticity mentioned earlier.

PROBLEMS ASSOCIATED WITH THE MAINSPRING

There are two disadvantages with any spring. Using the example of the school ruler, the more you play with it, the more the ruler will become bent like a boomerang. This is due to the internal structure of the ruler becoming stretched from being bent so many times and thus losing some of its elasticity. The other more dramatic outcome is that the (plastic) ruler would shatter into pieces.

As watches and clocks evolved it was soon found that they had the same problem as you with your broken/bent ruler, largely because the earliest springs were made by hand by blacksmiths in steel. Thickness would vary along the length of the ribbon of spring, and the quality of hardness would also vary. The quality of the steel itself was also (at best) poor. Like your ruler, this could cause the spring to lose its shape.

The uneven thickness would cause a third problem. A spring that has different thicknesses along its length causes a variation in the power of the movement. This in turn caused the watch to run at a faster or slower speed, leading to poor timekeeping.

Early springs, being made from carbon steel, tended to suffer from rust. This happened if moisture managed to sneak inside the watch, leading to deterioration of the steel and ultimately the spring breaking. This is where the old wives' tale of 'Careful you don't overwind your watch, you'll break the mainspring' originated. However, in this day and age of modern materials, this sort of problem doesn't affect mainsprings, as they are now made from a type of steel alloy which is resistant to rust. Not to mention that most modern watches have some type of water-resistant case to keep the moisture out.

Thus modern springs hardly ever break or lose their shape like your ruler, unless they are poorly handled by a careless watch repairer. In the sixties, this modern spring coined the name ‘unbreakable’.

The problem with a spring is that the flow of power varies as the watch runs down. This means it will affect the timekeeping of any watch. This is similar to a car that cannot accelerate smoothly in a traffic jam. To help combat this problem, there have been some very interesting inventions over the years. It is mainly through the improved materials we use today that this problem has been greatly decreased.

The mainspring is located in a hollow gear known as the barrel. As mentioned previously, the mainspring is basically a long ribbon of spring steel which has been coiled inside a hollow cavity. One end of the mainspring is fixed to a hook on the barrel arbor. During the action of winding, the barrel arbor rotates. As this happens, the mainspring winds around its diameter. On the other end of the mainspring there is a second hook, and this locks/hooks into the inner wall of the barrel. It is this end of the spring that pulls on the barrel wall, ultimately rotating the barrel to drive the watch by providing a constant force on the mating pinion in the train (gearbox) that the teeth of the barrel mesh with.

RUNNING TIME

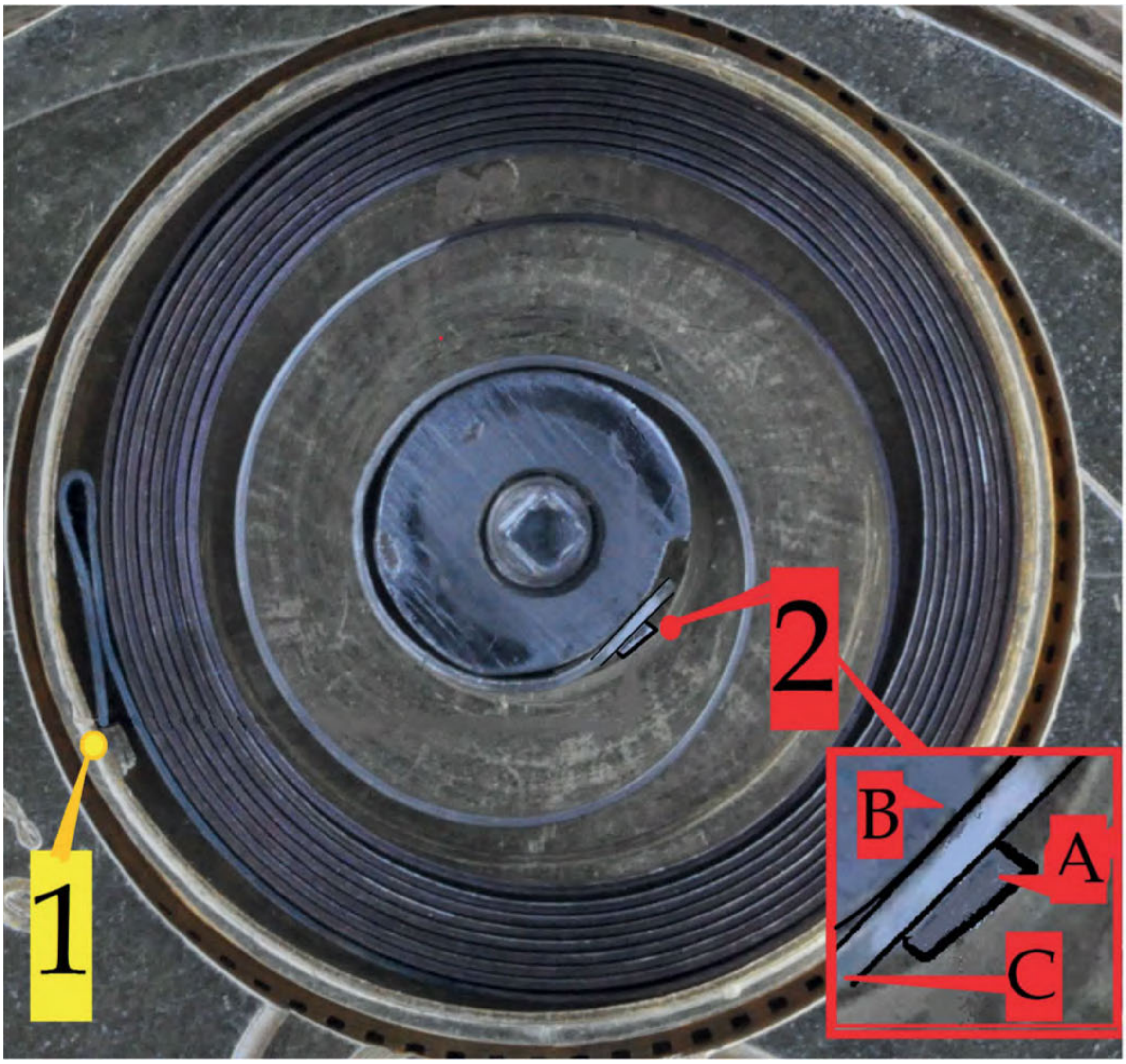


Fig. 99: A mainspring in the barrel in an unwound condition. (1) The hooking point of the mainspring on the barrel wall. (2) Hooking point of the spring on the barrel arbor. (A) Barrel arbor hook. (B) Barrel arbor. (C) Mainspring.

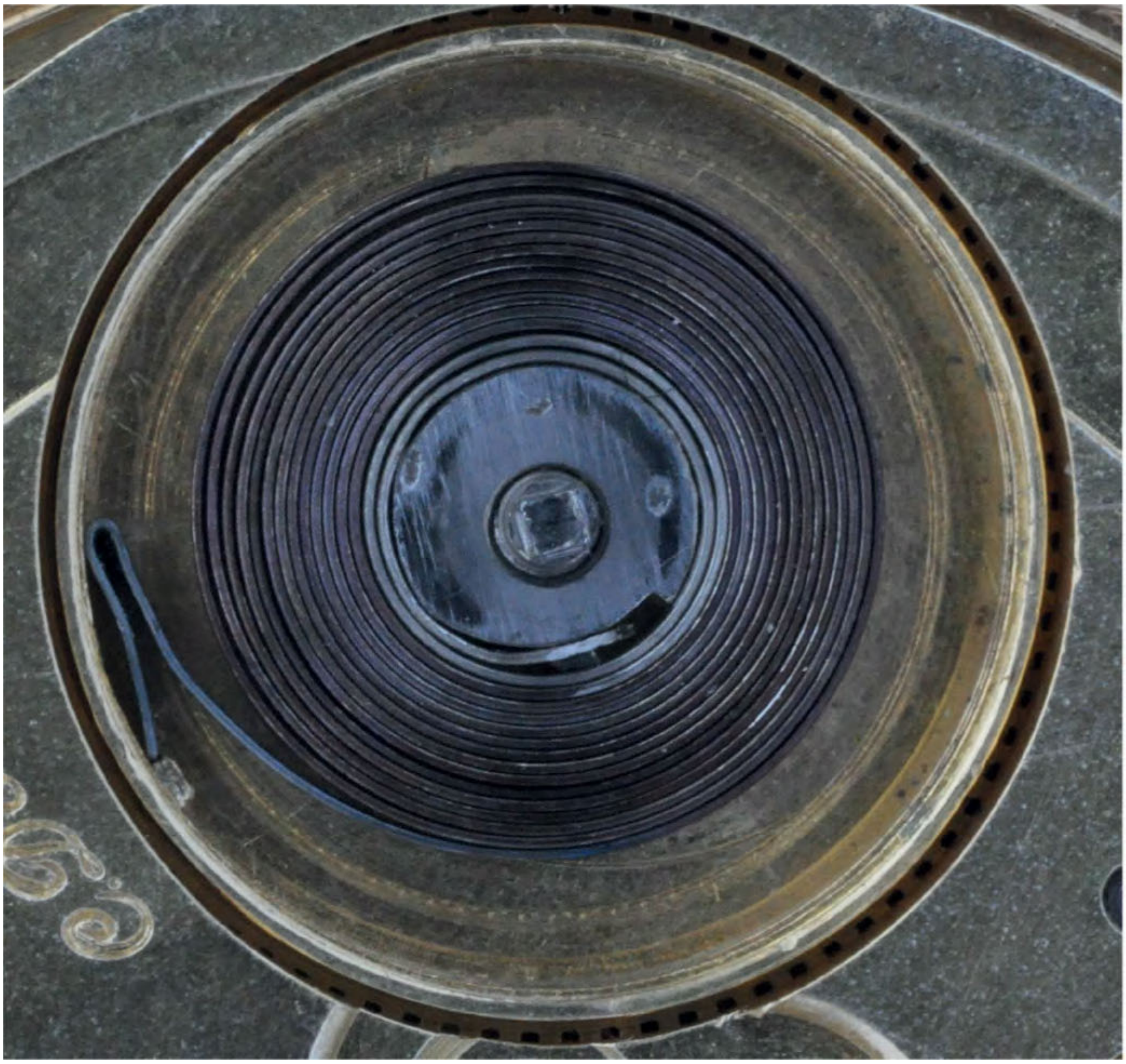


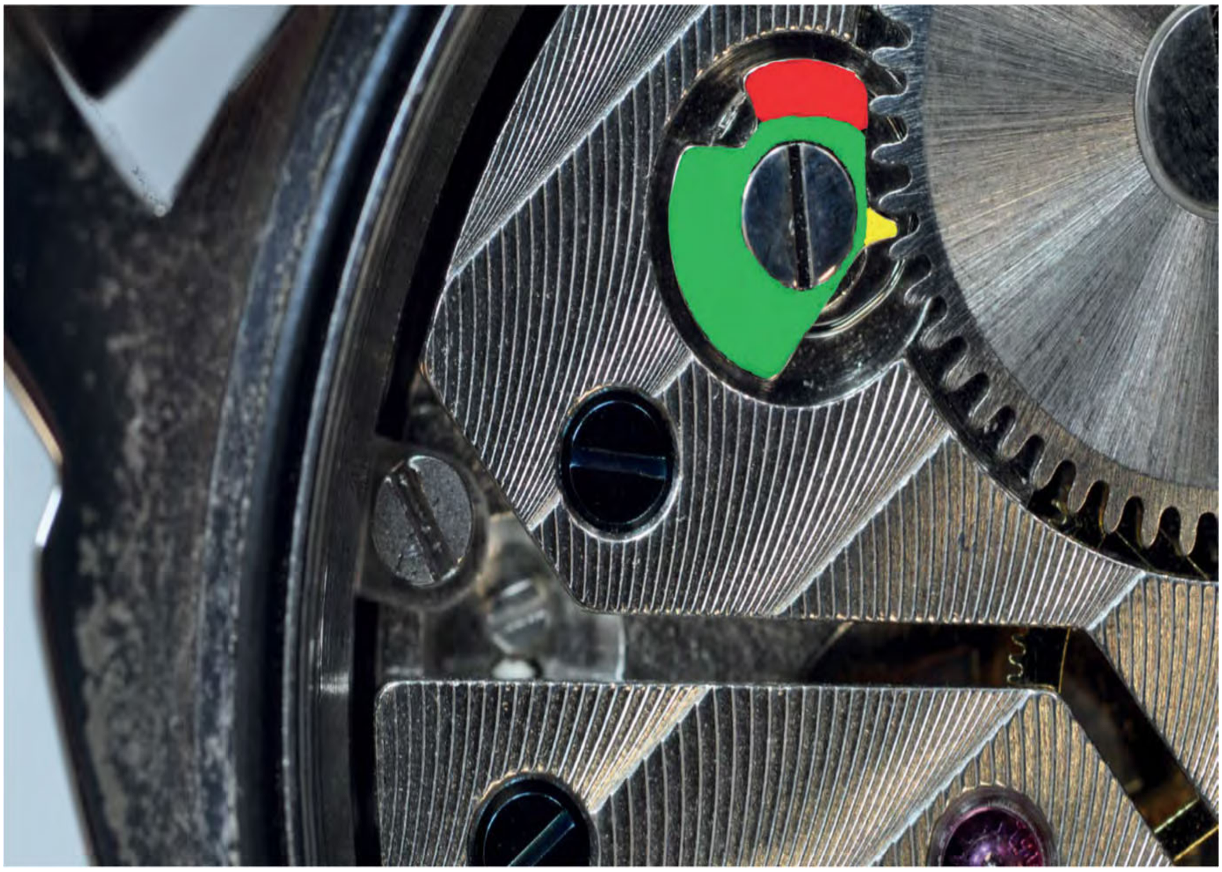
Fig. 100: A mainspring fully wound. The spring is wrapped round the barrel arbor.

If you fully wind your watch, then the entire mainspring will be fully wound around the barrel arbor, forming a spring-loaded mass at the centre of the barrel. You should be unable to wind it any further. What you can feel when the watch is fully wound is the end of the spring pulling on the inner wall of the barrel. Eventually, when the watch has ticked away for many hours, and the barrel has rotated many times, the spring slowly uncoils from the barrel arbor and relaxes around the wall of the barrel as the spring tries to regain its natural shape. When the energy is depleted, all of the spring will be hugging the outer wall of the barrel.

The energy is released through the gears that the barrel is meshed with in the gearbox. This is not an instant release of energy, as most watches have to work for between thirty and forty hours at a time. In real time the barrel is like one of Nature’s flowers opening from a closed bud – you know it happens, but it’s normally too slow for us to see. The average barrel has to rotate between seven and ten turns to keep your watch running for its allotted running time.

If you thought a watch ran on a random spring, you would be mistaken. The running time is determined partly by the number of coils wound into the barrel, and this is determined by the thickness of the ribbon of spring. Although the spring takes up a small space, the amount of energy it stores would also be less, compared to a thicker spring. You can hopefully see that there has to be a careful balance, due to the limitations in the amount of energy required to run a watch.

Think about a car: a larger engine would use more petrol as compared to a smaller engine. It would also be capable of pulling a heavier load. The bigger the watch movement, the larger the spring needed to drive it, thanks in part to the increased weight of the components needing to be moved. This is most easily compared to a mechanical clock – if there are fewer components, less power is needed and therefore (typically) a smaller spring.



17. REMOVING AND REPLACING THE CLICK

Fig. 101: The click (depicted as a chicken's head).

The click is designed to stop the mainspring from unwinding, and to hold the energy stored in the spring. It will nearly always be located next to the ratchet wheel (the big steel wheel on the back of the watch).We did have a brief look at this earlier when we were looking at the keyless work.

Clicks come in many different forms, and the one fitted to this watch is one of the most common. It is basically like a chicken's head in shape, with the beak riding over the teeth of the ratchet wheel during winding.

REMOVING THE CLICK

To remove the click, let down the power of the mainspring. Place the watch movement in a movement holder with the ratchet wheel facing you. Take a piece of peg wood. Rotate the winding crown with your free hand and turn it very slowly, as you would to wind a watch. When you see the click just about to ride over a tooth of the ratchet wheel, stop turning the winder and hold it there. Use the peg wood to rotate the click upwards, away from the ratchet wheel, and hold it there.

Loosen your grip very slightly on the winder very slowly, and it will rotate between your fingertips. You should also see the ratchet and crown wheel rotating in the opposite direction from winding.

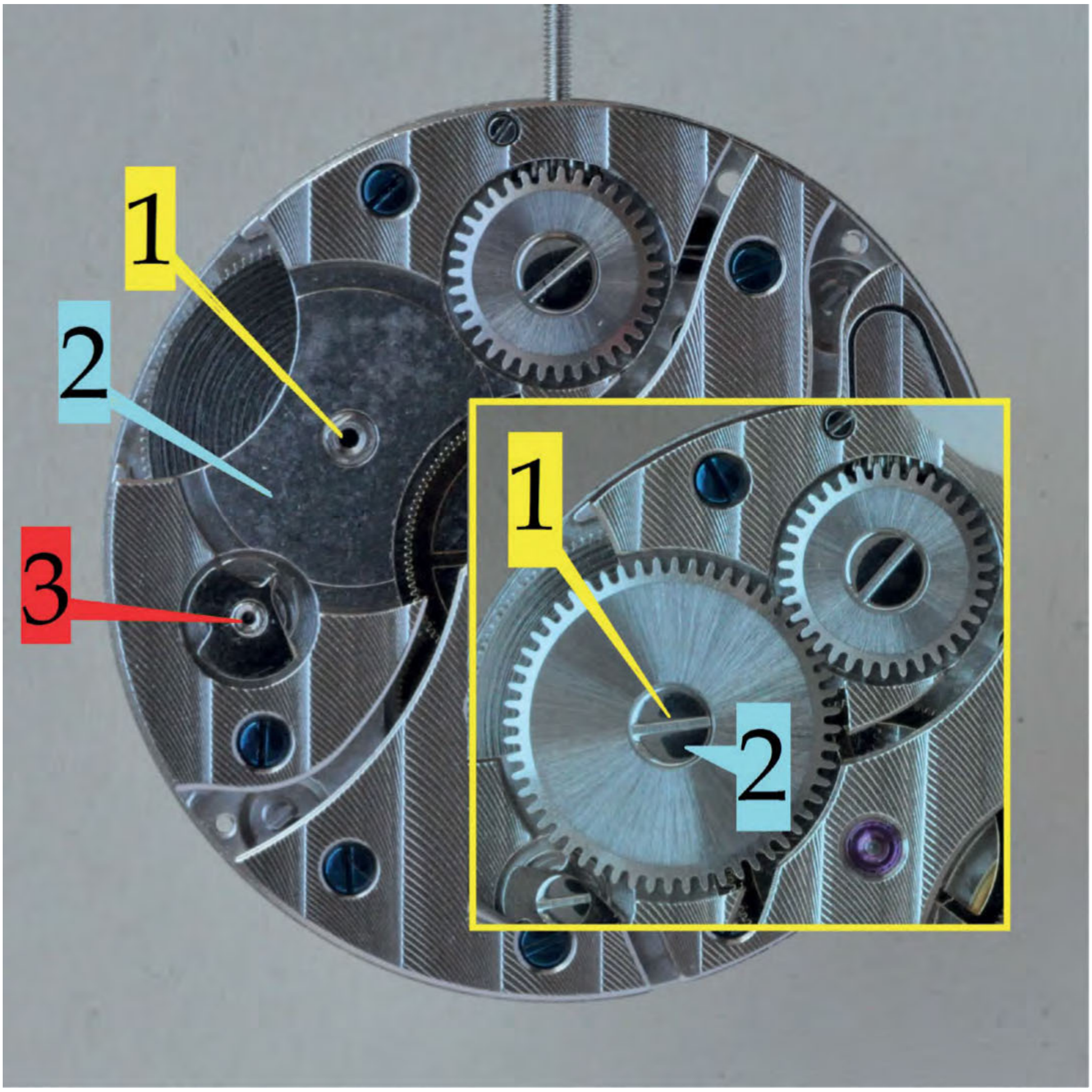


Fig. 102: Parts removed in the numbered order.

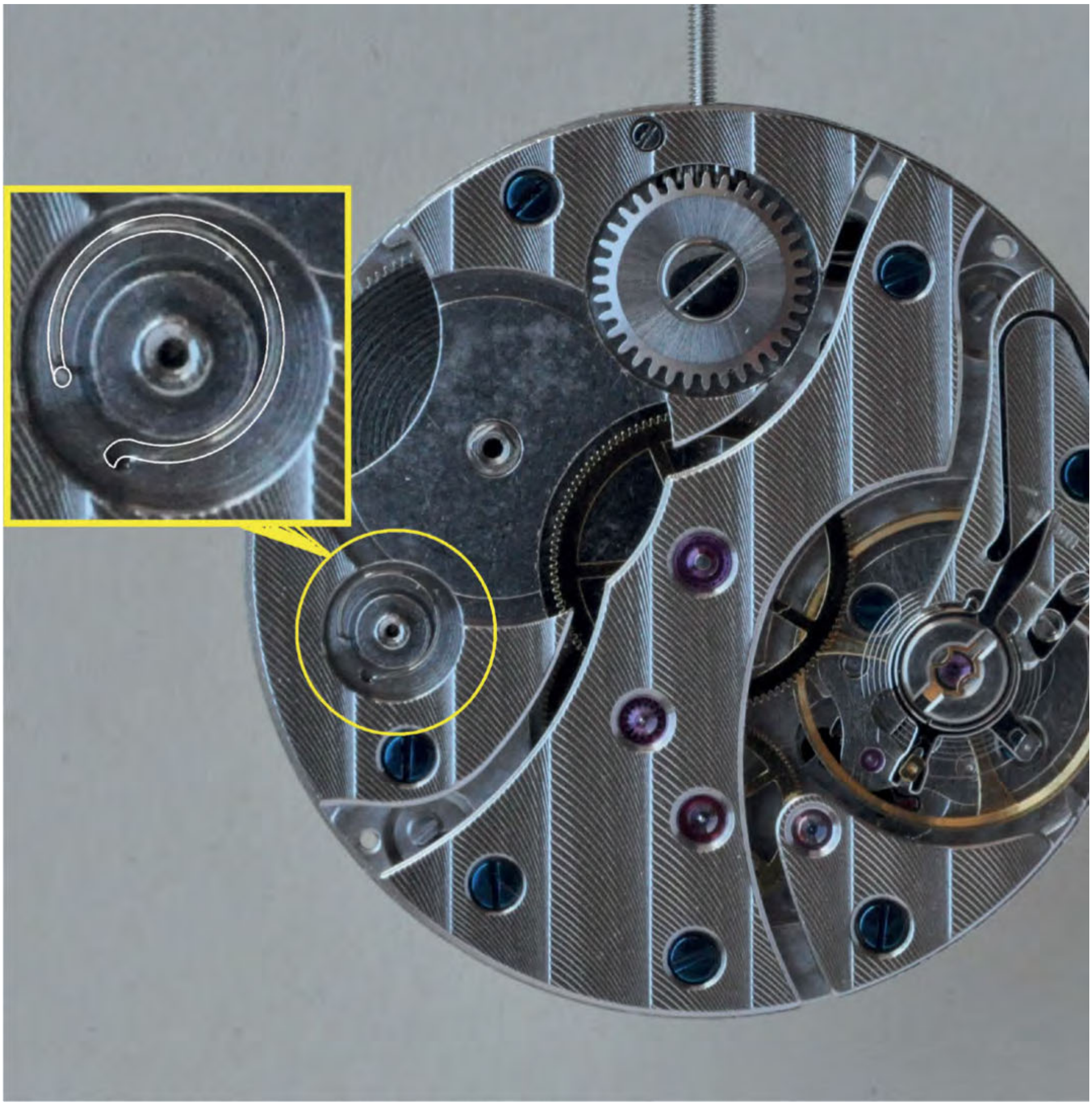


Fig. 103: The revealed click spring.

The Click in Closer Detail

Providing that you have let the power off, it is now safe to remove the ratchet wheel (the larger steel gear). Once I have let down the power I always remove the ratchet wheel to make doubly sure that there is no power left in the spring, as you definitely don't want watch parts flying across the room.

Remove the screw that is holding the click captive. Once removed, you will see that there is a post at the centre of the click, on which it rotates. You may also notice that there is a piece of round wire poking up behind the ‘chicken comb’: this is one end of the click’s spring that makes the ‘beak’ ride over the ratchet wheel’s teeth.

Carefully lift out the click and place it and its screw in a pot for safekeeping.

Take a look at the post. Next to it is a channel somewhat like a moat. It is a small distance away from the post, and in it is a spring wire shaped like the letter C. This spring has two extra bends that at first will not be obvious. Looking down at the spring, one end of the opening of the C is bent down and disappears into a hole in the barrel bridge. The second end is bent upwards, and this second bend is where the spring operates with the click (the bit behind the chicken’s comb).

REPLACING THE CLICK

If you replace the click you should now understand the following: wind the watch and observe the action of the click as it rides over the teeth. Examine the click closely, looking at what would be the back of the comb of the chicken’s head. You should just see part of the bent-up spring poking up, away from the barrel bridge. As the click rides off the teeth of the ratchet wheel, you will see the click pulling back the spring. As the second end of the spring is anchored in a hole in the barrel bridge, the spring is bending. It is this energy that pulls the click back towards the ratchet wheel.

Stop winding, and as you do, watch the click very closely: you should see it being drawn into the ratchet wheel as the tip of the chicken beak is drawn into the root of one of the ratchet wheel’s teeth. If you look at the ‘forehead’ or ‘comb’ of the chicken, this headbutts the ratchet wheel as it is drawn in by the wheel trying to unwind. This ultimately halts the rotation of both the click/ratchet wheel, and holds the power of the mainspring.

This small amount of recoil has been designed carefully, and it serves an important task, ensuring that the spring is never totally fully wound. This means that the mainspring hook is never overstrained on the barrel wall. It also allows the mainspring to relax a fraction of a turn.

This type of click is given the name ‘recoiling click’. This small amount of unwind of the spring helps prevent excessively high power, which helps for more accurate timekeeping. An over-tightened spring (loosely termed ‘over-wound’ spring) would lead to excessive gaining and, over a prolonged period of time, damage to the mainspring.

18. REMOVING THE BARREL BRIDGE, CAP AND ARBOR

Let down the power of the mainspring again, then you will need a suitable screwdriver to remove the ratchet-wheel screw. Once this is off, you can now lift out the ratchet wheel.

REMOVING THE BARREL BRIDGE

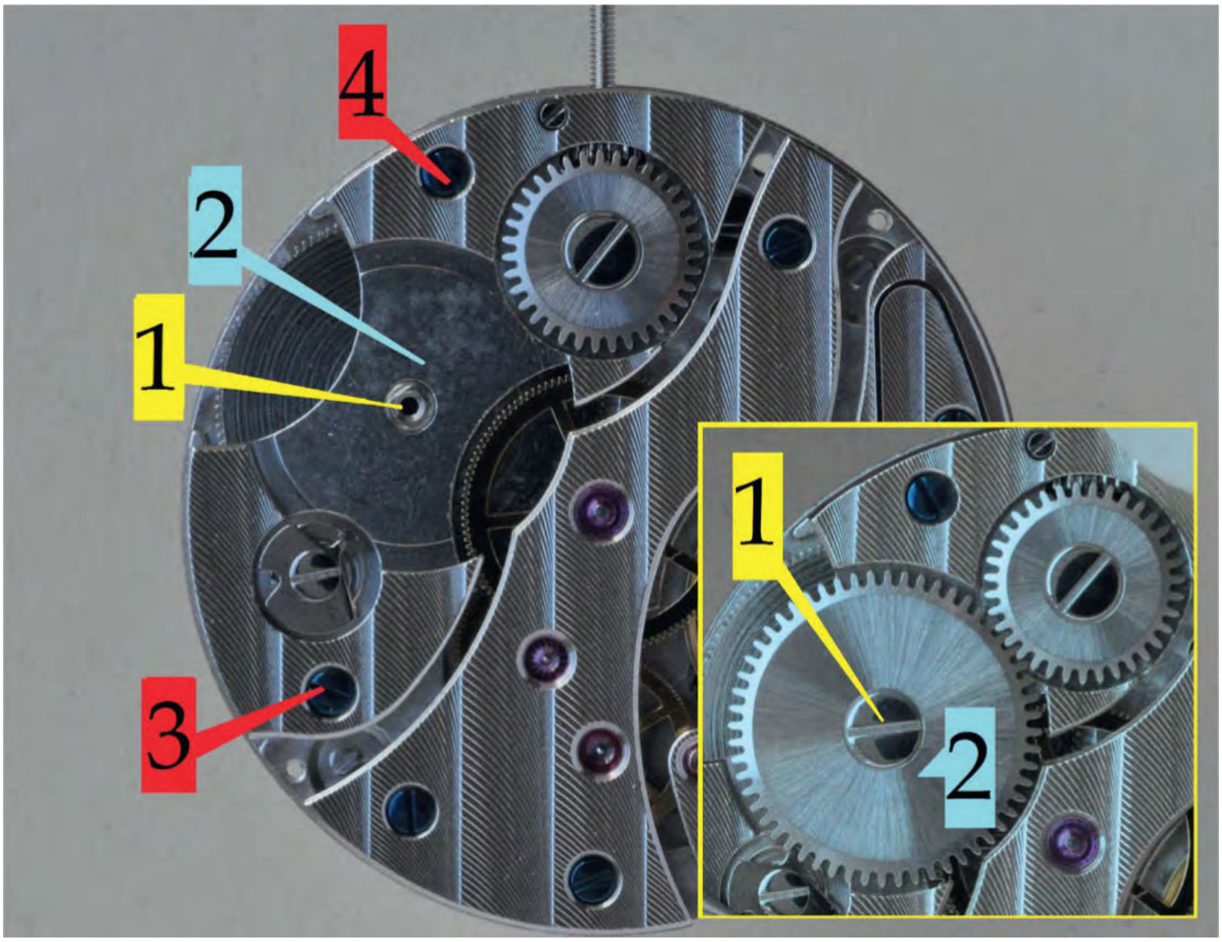


Fig. 104: Remove in the numbered order.

Remove the three screws holding down the barrel bridge; once you have done this, you can remove it. To help lift it off, the manufacturer has made little cut-outs on the outer edge of the bridge just where it meets the plate, so you can fit a small screwdriver blade in this slot and lever it upwards. This helps you remove the bridge by releasing its steady pins from the base plate. Once the plate is free it can be removed with the aid of your tweezers and placed in a storage container.

Now that the bridge has been removed, you should clearly see the barrel itself. This too can be lifted free of the watch by grasping it by its arbor with your tweezers and lifting it out.

To get a look at the mainspring, first you will have to remove the barrel cap. Some watches have a small section cut out of the cap on its outer edge, so you can place the blade of a small screwdriver into it and lift the cover up carefully until it pops off. Most modern watches do not have this facility, so the cover will need to be popped off by pushing on the arbor from the opposite side.

REMOVING THE BARREL CAP

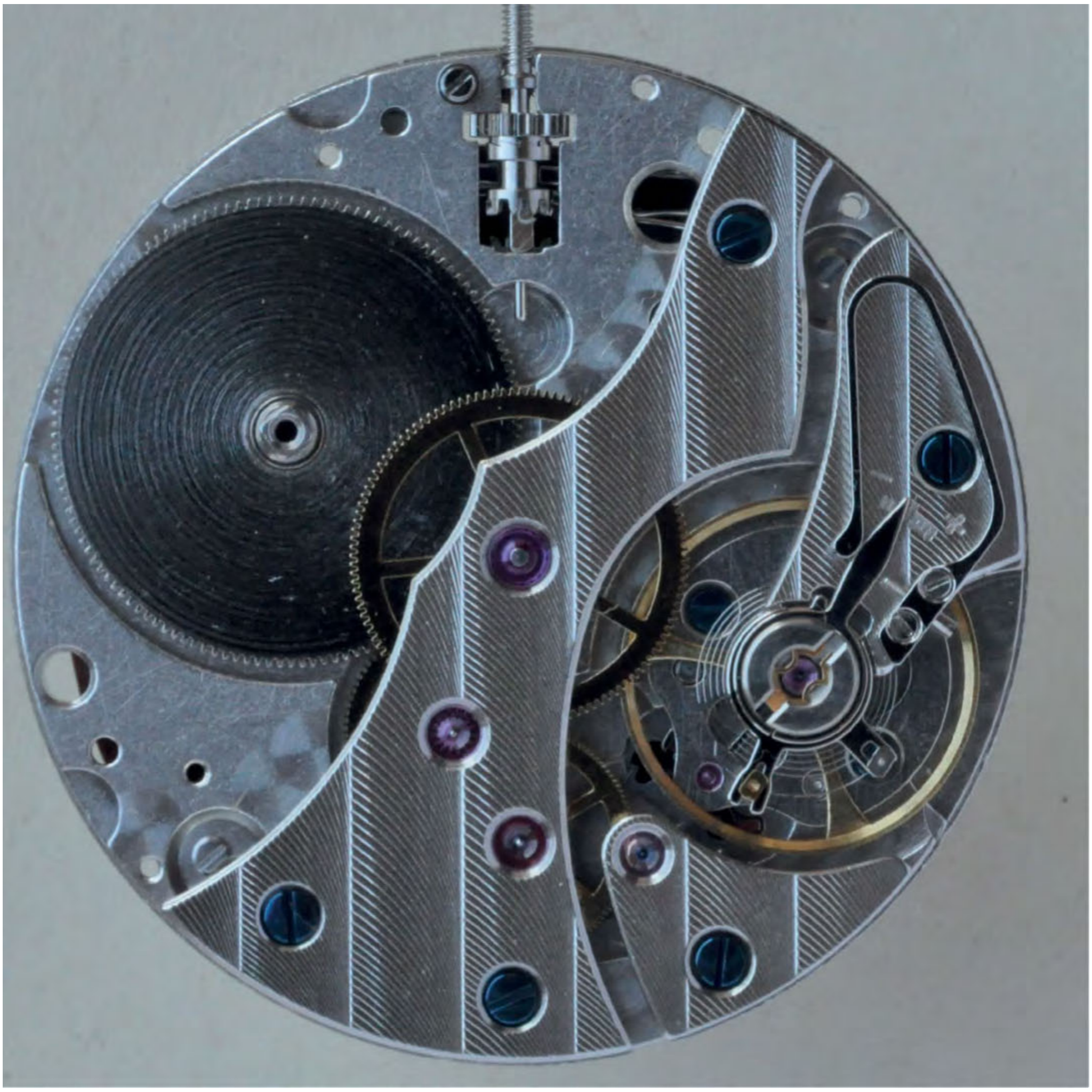


Fig. 105: The revealed barrel.

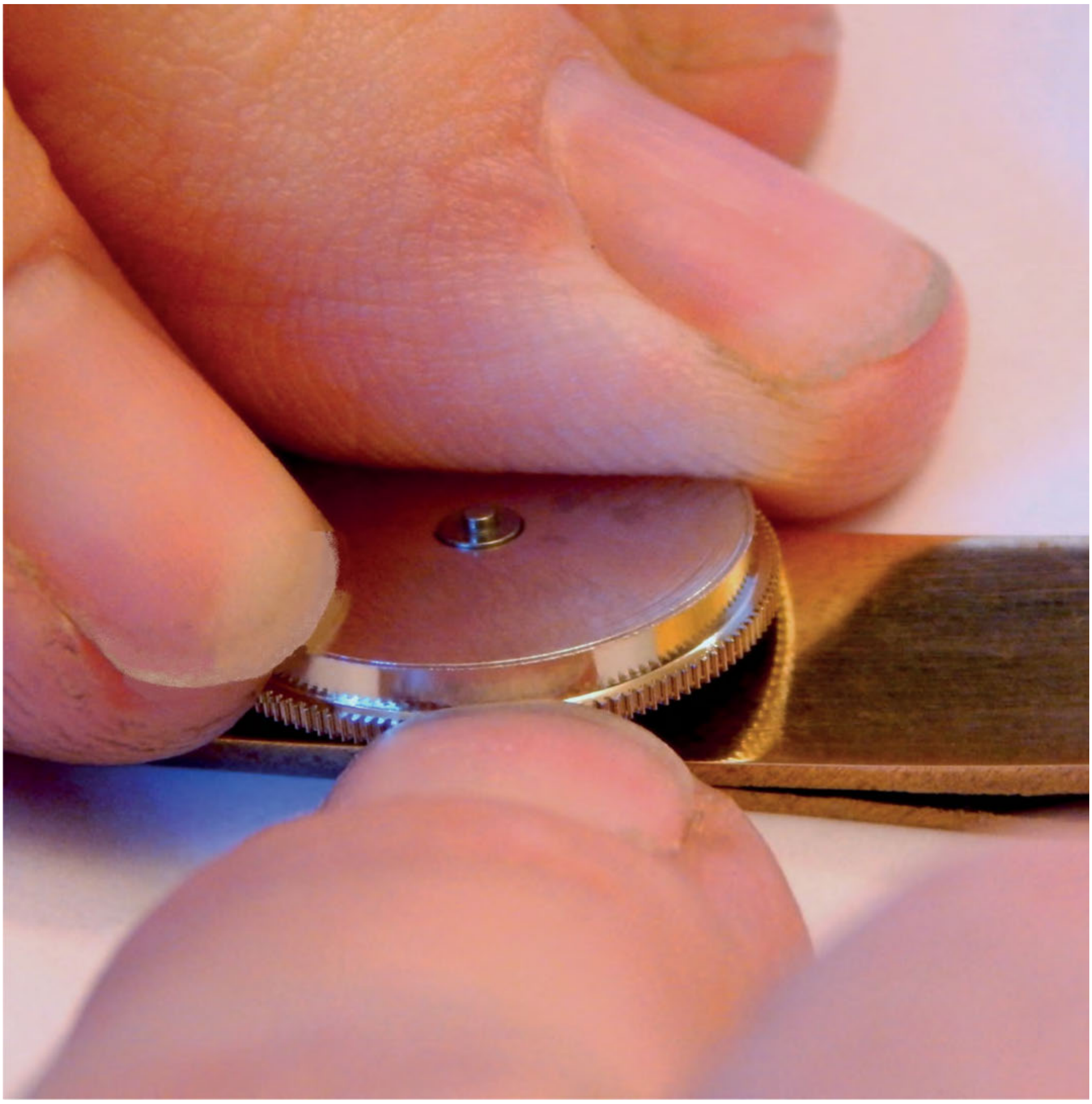


Fig. 106: Removing the barrel cap.

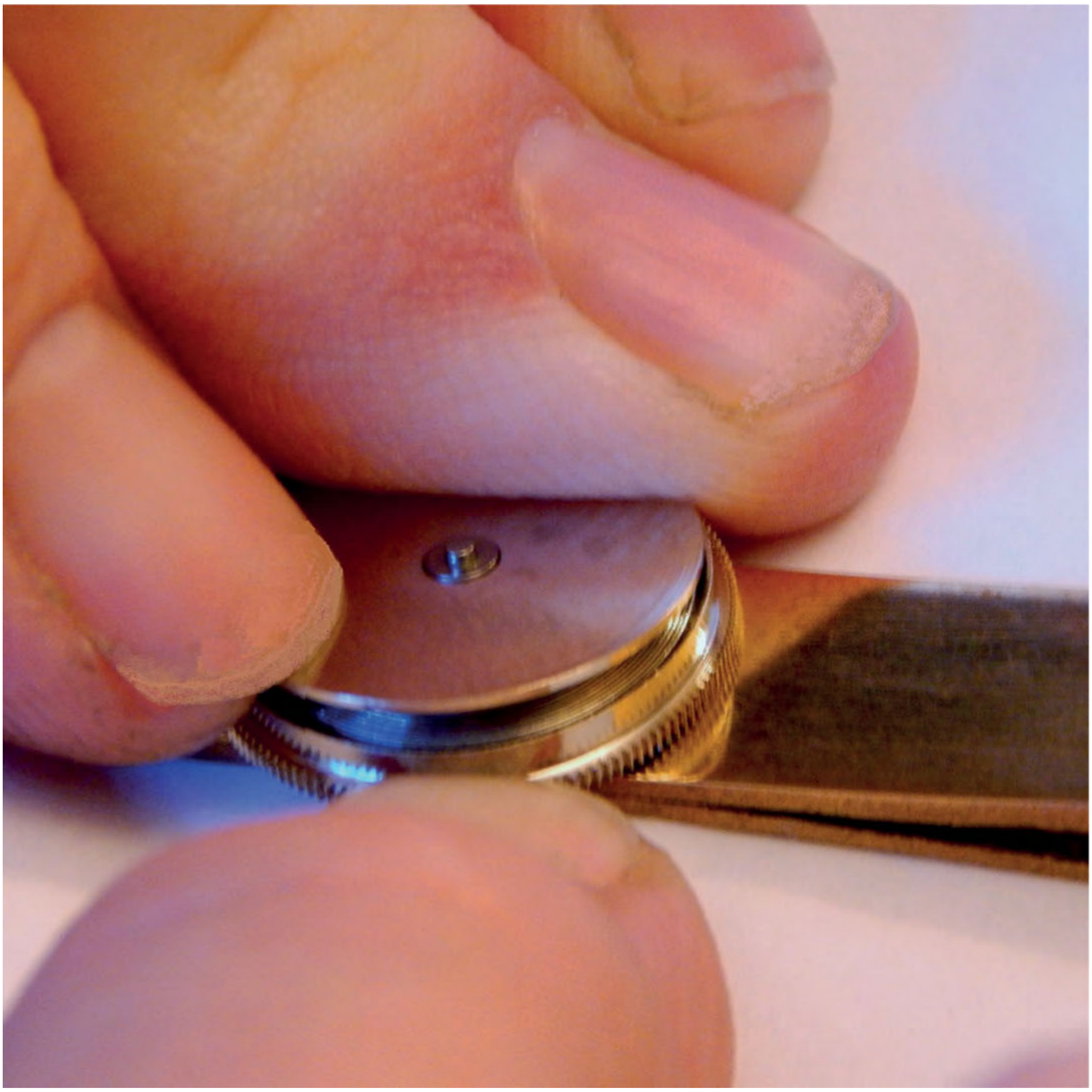


Fig. 107: Freed barrel cap.

To remove the barrel cap, place your tweezers on the bench in front of you. Place the barrel on the rounded end of the tweezers, making sure the barrel arbor (the end with the hole) is standing on the tweezers and not on the short stubby pivot.

Support the barrel with your left thumb and index finger. Using your right-hand thumbnail, push down on the teeth of the barrel. If you use sufficient pressure, you will hear a pop and the barrel cover will be released from the barrel.

Carefully remove the cover, taking care that the barrel arbor remains in the barrel and is not removed with the cap. If this happens, the spring is likely to fly out of the barrel, causing the barrel and spring to fly in different directions. You may need to hold the cap with your left fingers and ease the arbor out of the cap with the tweezers in your right hand.

With the cover removed, look at the barrel arbor. You should be able to see where the spring is fixed to it.

REMOVING THE BARREL ARBOR

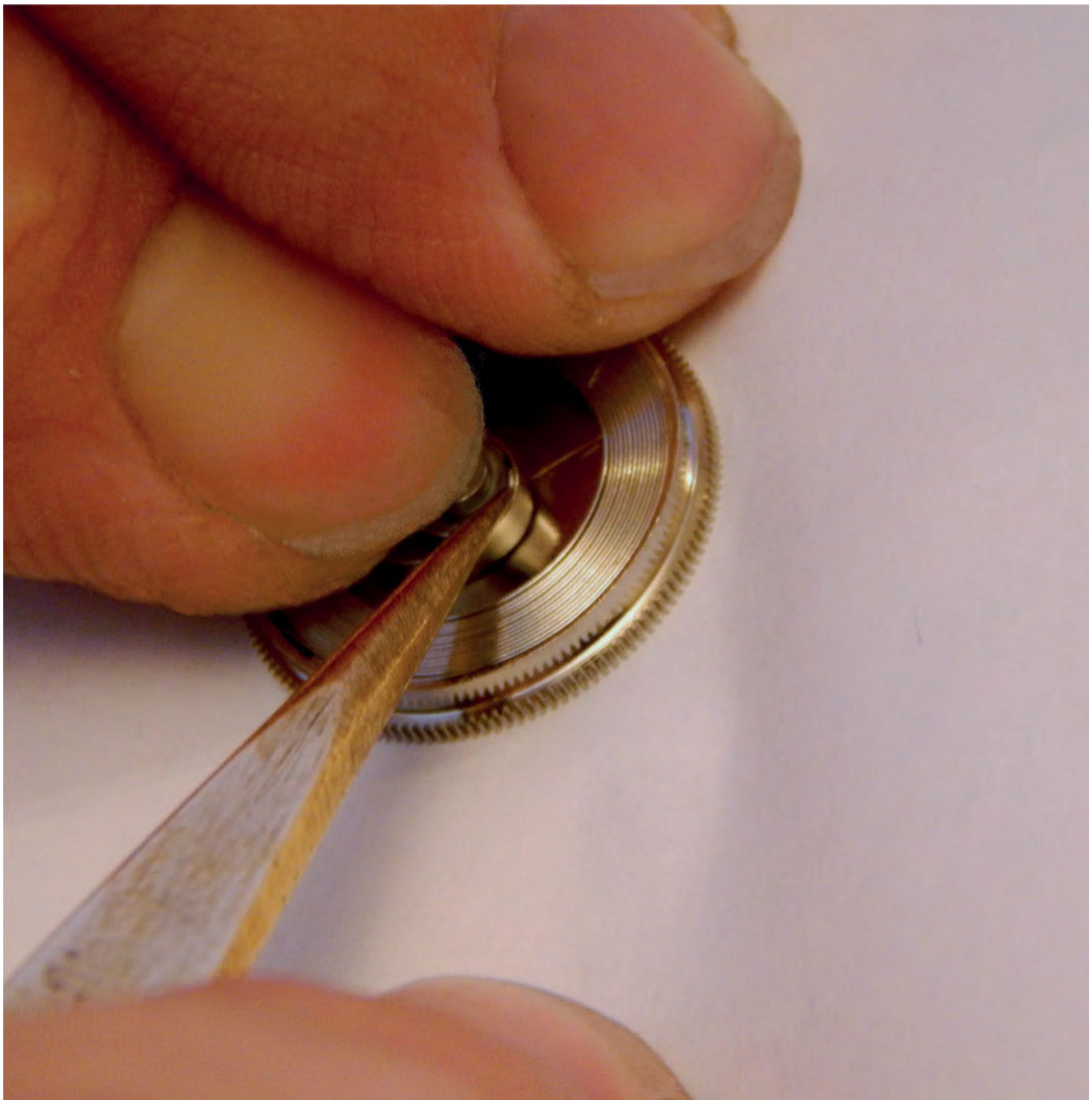


Fig. 108: Easing the spring off the barrel arbor.

Place your left-hand thumb and index finger over half of the exposed mainspring. With your tweezers in your other hand, pull the barrel arbor free from the spring. Once the barrel arbor is free, it can then be removed, making sure to keep your fingers over the spring the whole time.

19. REMOVING AND REFITTING THE MAINSPRING

REMOVING THE MAINSPRING

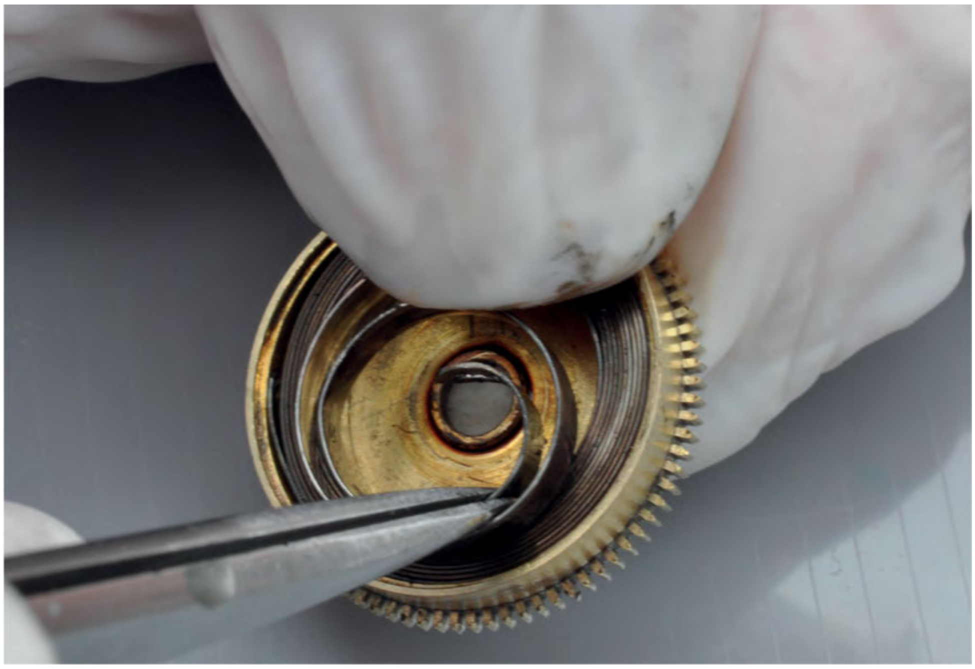


Fig. 109: Easing the first coil of the spring out of the barrel.

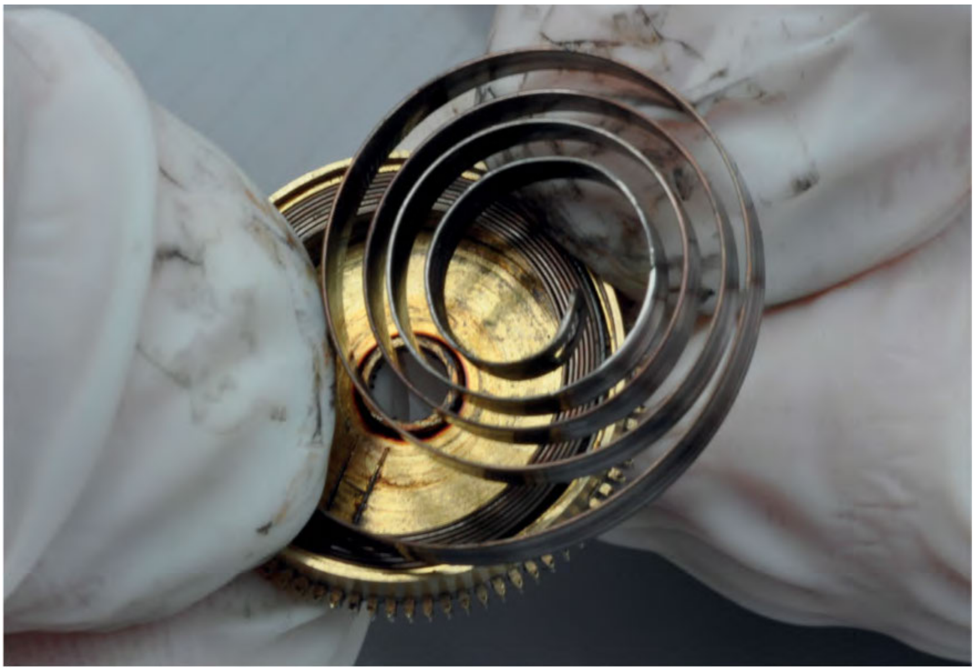


Fig. 110: Winding the rest of the spring out of the barrel.

To remove the mainspring, first pick up the barrel with your left hand. With your thumb on the top, covering only one third of the spring and leaving the centre coil uncovered, place your index finger on the underside and squeeze slightly.

With your tweezers in your spare hand, pull on the first coil to free it from the barrel. At the same time, keep a firm grip on the barrel with your left hand.

Now put your tweezers down as you will need your right hand to ease the spring out of the barrel.

With the centre coil free, you need to grasp the barrel with your now free right hand. Once you have a grip on it, let go with your left hand and a small amount of the free spring will wind out of the barrel.

Grab the barrel with your left hand again, and loosen your grip with your right hand. Again a small amount of spring will wind out of the barrel.

Continue with this careful shuffling method using your fingers so the mainspring unwinds slowly out of the barrel. Take care not to let it suddenly pop out all at once.

Once the end of the spring is in sight, you must unhook it from the barrel wall using tweezers. Failure to do this will cost you the price of a new spring, as the hook can be easily broken off during the final stages of removal. Therefore, make sure you have a pair of tweezers to hand, as this operation really requires three hands.

Now that the spring is out of the barrel, you can clearly see its typical ‘S’ shape. If you have removed it carefully, when placed on the bench, the spring should be flat and there should be no kinks along its length. If there are, it should be replaced as soon as possible; but if you are just using this watch for practice, then put it back at your earliest convenience.

CLEANING THE MAINSPRING

Before you refit the spring back in its barrel, you must clean it to remove the old grease and any acid from your fingers you may have put on it.

Ideally, use watch repairer’s degreaser; there are several brands on the market, and they are all fairly similar. If you are impatient and can’t acquire any degreaser quickly enough, then *as a last resort* you can use lighter fluid. I personally would not, as links have been made between some watch repairers in the past who have used lighter fluid and respiratory illness in later life. You must always think about your own health and safety during your projects, however using these products once or twice should not be overly hazardous. Other down sides to using liquid petroleum products are that they have a very strong odour, and they are highly flammable.

To clean the spring you will need a lint-free cloth. This is a good time to break out the unwanted hankies from Christmas and put them to use. Do *not* be tempted to use paper tissue, as this will leave little bits of fluff along the length of the spring.

Next, take your degreaser of choice and apply a small spot of this on to the cloth. Wipe the length of the spring, starting from the hook end. The best method is to pinch the cloth on the spring, using your index finger and thumb, and run it along the length of the spring right up to the centre coil. If you have one of the old blue- or brown-coloured springs you will have to take more care, as these are much more fragile. Try not to straighten them out, but instead work your way around them.

Tip: When your cleaning cloth starts to look rather grubby (after a dozen or so uses), you can put it in the washing machine on a hot wash – though it might be as well not to mention it to the wife/partner… they just wouldn’t understand!

Now your spring is nice and clean, you will have to refrain from handling it directly, as you will contaminate the surface with the acid from your skin. This could cause the spring to rust or corrode in the future. If you must handle the spring, use a clean set of finger cots, *not* tissue paper.

REFITTING THE MAINSPRING

The only satisfactory way of refitting a spring without distorting it, is to use some sort of mainspring winder.

If a mainspring becomes distorted by being incorrectly fitted by hand, it will cause excessive friction in the barrel and therefore a loss in power. As the coils of the distorted spring inside the barrel try to relax, they try to twist, causing the spring to dig into the barrel's surface.

Important note: If you fit a spring by hand there is no way of knowing if you have damaged the spring or not. Many watchmakers of old have managed to fit a spring by hand without damaging it by using the lightest of touches, but this is *not* recommended.

A mainspring winder is straightforward and all but clinical to use. Put very simply, the spring is wound into the tool and then injected into its barrel. These winders are expensive and can be a bit fiddly, but they are worth using. If you are just starting out, I will forgive you if you have to refit the spring by hand, but for best practice please consider getting a Swiss-style mainspring winder.

The Mainspring Winder

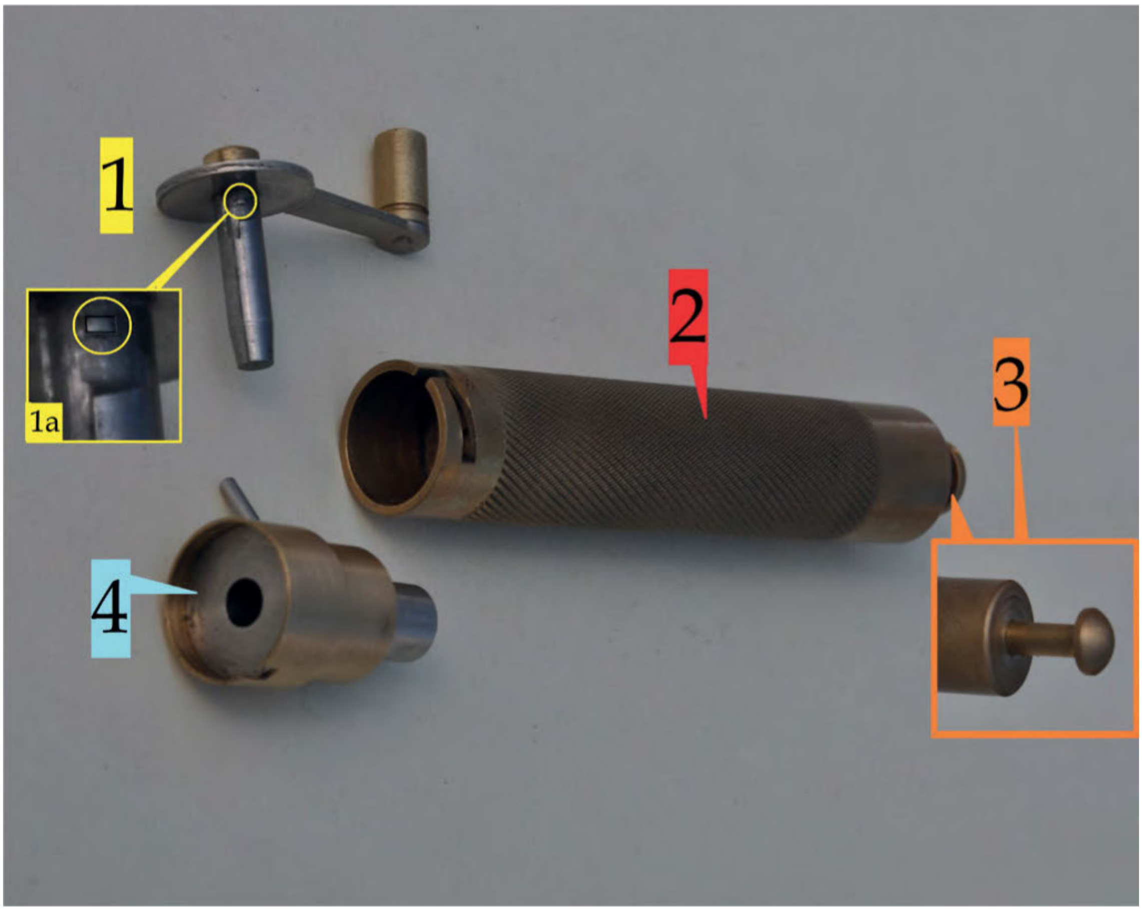


Fig. 111: Swiss mainspring winder. 1: Crank key. 1a: Hook. 2: Injection handle. 3: Injection button. 4: Barrel insert.

Quality winders normally come in smart wooden box sets ranging from 7 to 17 barrel inserts. They are normally graded by their size, with an imperial numbering starting with 00 (the smallest) to 15 (the largest).You can also purchase left- and right-handed sets. This is because in some watches, the spring is fitted in the opposite direction to the barrel. It is most common for the spring to wind in the barrel in a clockwise direction. You can normally tell the difference between these sets quite easily because the manufacturer puts a blue (left) or red (right) dot on the centre of the crank key to indicate the direction of wind.

There are cheaper Indian versions of winder on internet auctions; these are normally made from aluminium and come in a box that looks as if it should have dominos inside. They can no longer be bought new, and are really not worth the second-hand price being asked for by their vendors; they really are inferior to the Swiss version.

Other watch manufacturers also have mainspring winders made for their models, but these are only available to authorized service centres. Still, a good 17 winder set will normally cover all, as well as the special brands (just about).

Fitting the Spring to the Crank Key

To use this tool, you will first have to find the biggest barrel insert that fits inside your barrel, as the spring will be wound into this part of the tool. If you choose one that is too small, you will only be able to wind a small part of the spring inside it.

Remove the crank key from the box and lift out the barrel insert. With your barrel insert of choice (probably a size 10 for this watch), put this into the ejection handle and twist the two together to lock securely.

You will have to work out which way round the spring must be fitted into the barrel; as previously stated, most watch springs are wound in a clockwise direction. I suggest lying the spring on the bench and looking at it. Examine the centre of the spring. You should see a hole. This is the hole that the barrel arbor's hook locks on to. It rotates the spring during winding in a clockwise direction to coil the spring around itself.

An analogy: Think of the spring as a snake. The spring's hole is the snake's eye, and the V hook is the tail. The snake has to slither forwards in a clockwise direction (wear finger cots when handling a clean spring). Keeping the spring in this orientation, slide the shaft of the crank key into the centre coil from underneath and slide the spring towards the underside of the handle. Make sure you locate the crank key's hook in the centre of the mainspring's hole (the snake's eye). If you fail to do this properly it is unlikely the spring's hole will catch the hook. Later on you will just hear a little clicking notice.

Proceed to dock the shaft of the crank key with the barrel insert, which should now be locked into the ejection handle. You will have to locate the flapping loose part of the spring in the slot of the tool to close properly.

Winding the Spring into the Tool

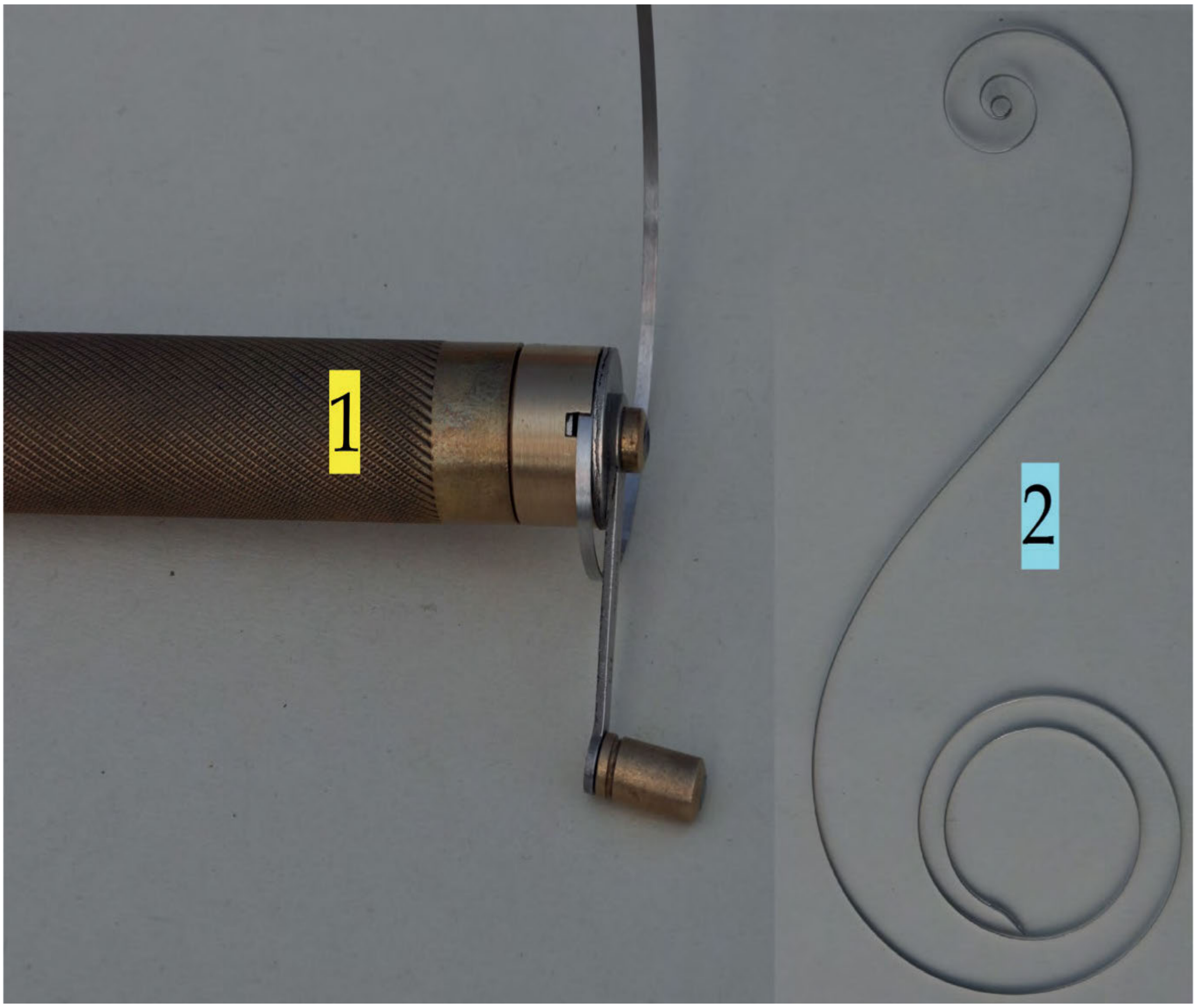


Fig. 112: 1: Winding the spring into the tool. 2: A modern Swiss mainspring with a reverse curve.

If you are right-handed I would suggest holding the tool in your left hand (wearing finger cots on this hand). Place a heavy duty set of tweezers at the ready in reach of your right hand.

Tip: When holding the tool you must be careful not to accidentally push the button on the end of the ejection handle with the palm of your hand. Mid-wind, this would cause the spring to fly out of the tool. If you are unlucky, the spring will slap your fingers. If the tool is close to your face, it will slap your nose, and let me tell you, it really smarts!

With the tool in your left hand, use your right index finger and thumb to rotate the crank key in a clockwise direction in a slow and controlled manner. Make sure you provide a *small* amount of downward pressure on the crank handle at all times, as this will also help prevent the spring from jumping out.

Keep winding the spring into the tool until about 1.5cm of spring is poking out. Move your left thumb so that it is pushing down on the centre of the crank key. The crank's handle will lock itself on the side of your thumb once your right hand lets go. This will stop the spring from unwinding and helps free up your right hand.

Remove your right finger and thumb from the crank key's handle, and grab your tweezers. Use these to feed the remaining section of spring into the tool. You may find that the hook refuses to enter. If this happens, turn the crank key's handle a quarter turn to make a bit more room for the hook to enter. Be very wary of overdoing it, as the hook can be easily broken off if it enters the tool too quickly.

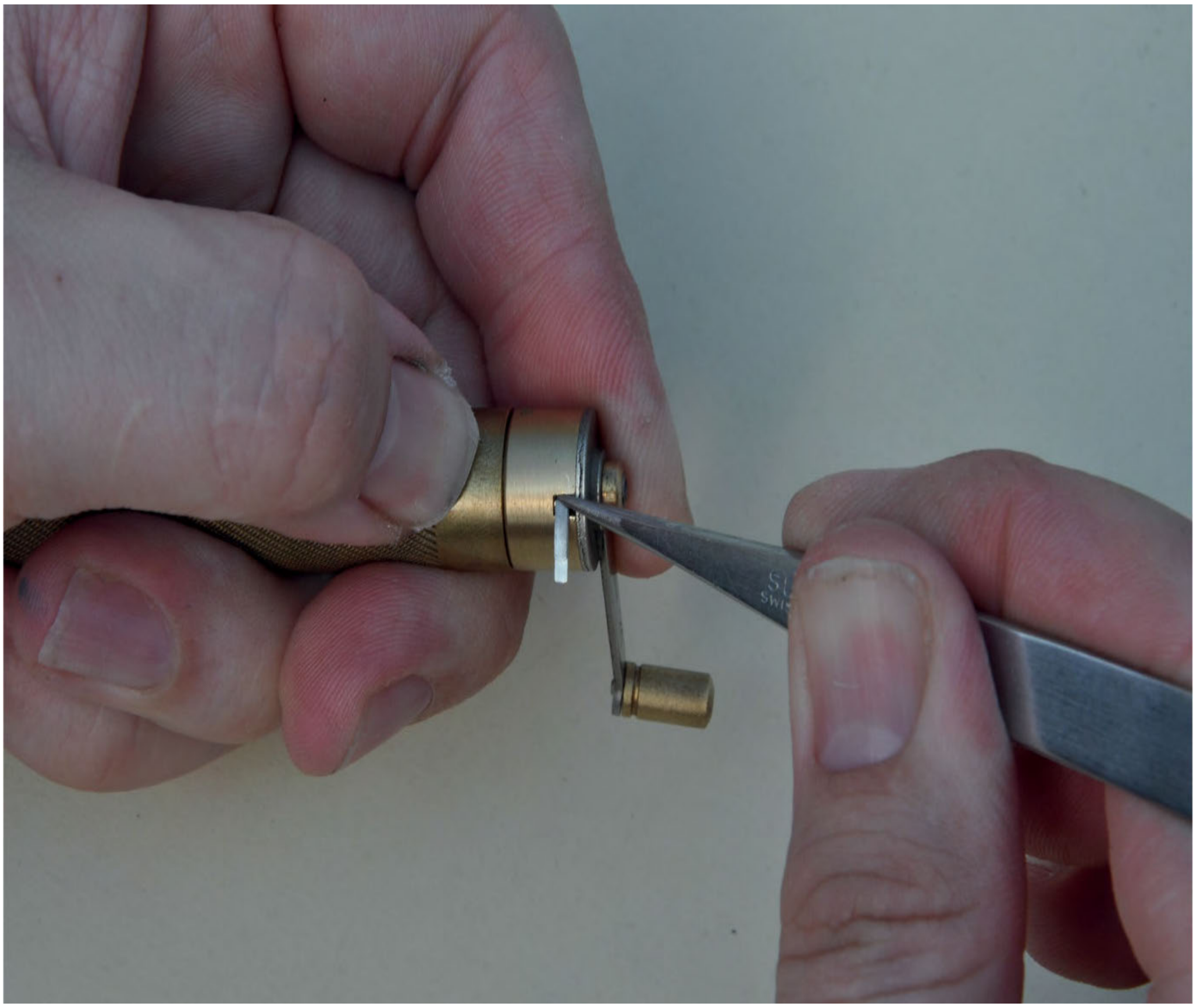
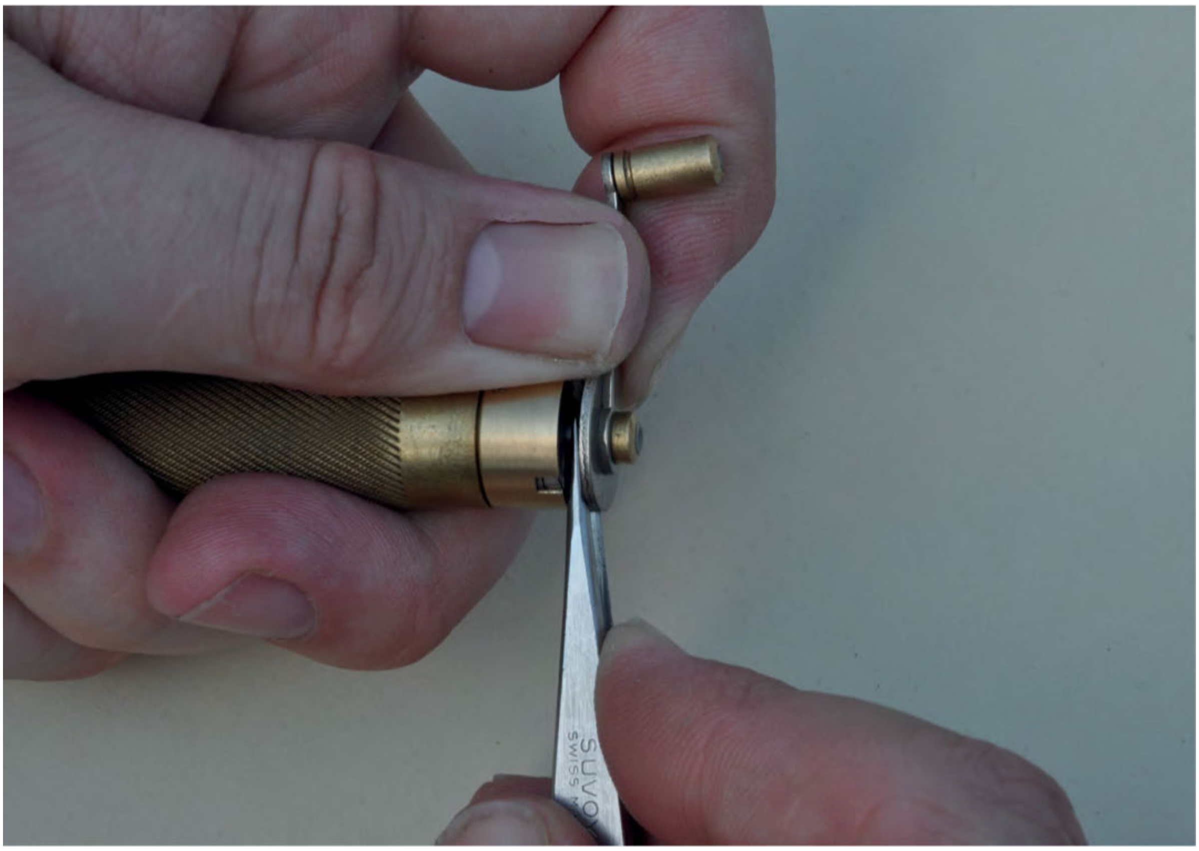


Fig. 113: Easing the hook into the tool.

Once the hook is safe inside the tool, the next task is to let off the remaining energy left in the spring. Turn the crank key slowly and carefully in an anticlockwise direction, until you can feel no tension from the spring.

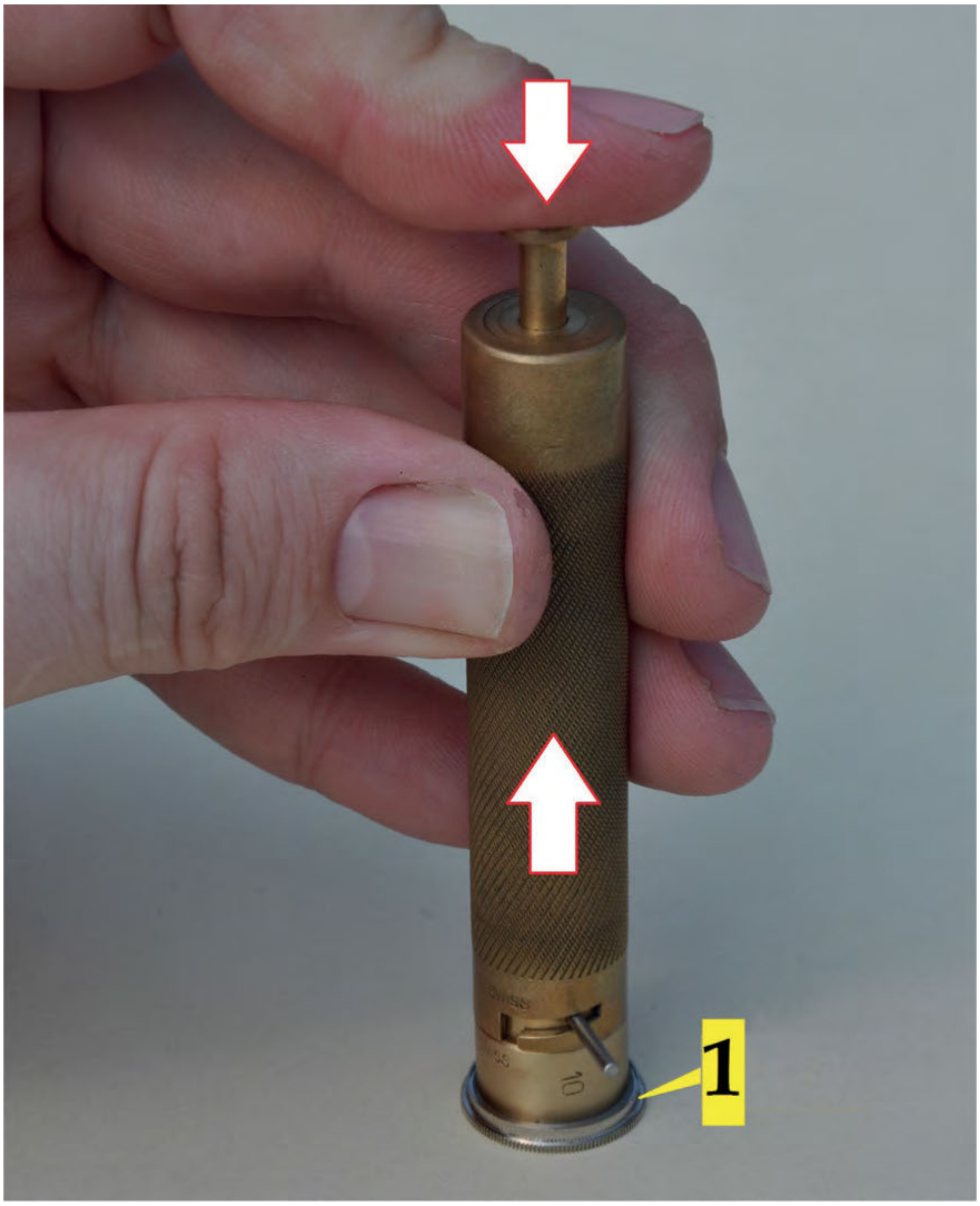


Removing the Crank Key

Fig. 114: Removing the crank key handle, using tweezers to keep the spring in the barrel.

Still holding the tool in your left hand and with your thumb back on top of the crank key, put your tweezers in your right hand. Use one of the tweezer tips to separate the crank key from the barrel insert: this ensures that the spring remains in the tool as the crank key is removed. As the tweezers enter the tool, use them as pincers and approach the shaft of the crank key from both sides. As the tweezers keep moving in, the crank key will slide out of the main part of the tool. The tweezers keep the centre of the spring secure in the tool.

Once the tweezers have lifted the crank out sufficiently, you can use your left thumb to keep the spring in place as you pull out the remaining part of the crank key.



Ejecting the Spring into the Barrel

Fig. 115: Injecting the spring into the barrel (1).

Before you eject the spring into the barrel it is a good idea to give the surface of the spring a quick clean with some Rodico. This will prevent any grit or contaminate entering the barrel and damaging the surface, preventing smooth transmission.

The next job is to grease the barrel floor. For this you will need a large oiler and Moebius 8200 grease or equivalent.

Place a very small amount of the grease on the barrel's base and cover. Using a large watch oiler (green or yellow), pick up a small blob of grease and apply three dots of the grease (the approximate size of the small pivot of the barrel arbor) to the barrel's base equidistant from each other, like the points of a equilateral triangle.

Insert the mainspring into the barrel. This is the relatively easy part, but if you are careless, the spring and the barrel will easily fly across the room.

Place the tool's barrel insert into the barrel, and hold it in this position with a very light grip. With your free hand, press the eject button on the end of the tool. You must apply a greater pressure to the button than that of the hand holding the tool in place.

If you apply even pressure, the spring will remain in the barrel insert, as the shaft of the tool needs to rise up in order to eject the spring.

Once the spring is fitted in the barrel, give the top surface of the visible spring a quick rub with some Rodico. This is to ensure no grit or other contaminate has found its way into the barrel with the spring.

Apply grease to the inside of the barrel cap. Again, use three droplets the size of the barrel arbor's pivot, and place these dots in a triangle.

To identify the inside from the outside of the barrel cap, there is normally a small lip to its outer edge. Also the cap's bearing will stick up round the hole in the centre. This bearing will be smaller than the diameter of the barrel's arbor; though if it is larger, it is safe to say that this is the outside of the barrel's cap.

Tip: To apply the oil and grease to the barrel, read the section about oiling. You will need a green or yellow watch oiler. As this is your first time, and you may not at this stage have all the basic kit, you could use a very small watchmaker's screwdriver as a temporary oiler for this job. It is important to realize that a screwdriver will be inadequate when it comes to oiling the rest of the watch as part of the eventual clean and service.

Fit the barrel arbor into a pin vice, making sure that the smaller end is in the vice, and that the end with the hole is peeking out of the pin vice.

Tip: When fitting the barrel arbor in the pin vice, make sure that the arbor is easily removed from the tool: it should not be a force fit, otherwise the barrel and spring will fly round the room in different directions when you try to extract the arbor from the tool.

Place the barrel on a barrel closing tool or a watchmaker's stake with the exposed spring facing you. Apply a heavy grade of oil (D5/HP1300/9020 or similar) on the bearing surface on which the barrel rotates. You may need to apply one or two dots of oil on the arbor's surface so that you can see a small bead of oil round the barrel arbor.

Push the barrel arbor (still held in a pin vice) into the centre coil of the mainspring. At the same time, rotate the pin vice a little in an anticlockwise direction, as this will help the spring wrap round the barrel arbor.

Once the barrel arbor slips into the centre coil of the spring, move to loosen the grip of the pin vice, making sure to maintain a small amount of downward pressure. This will prevent the barrel arbor from jumping out of the barrel.

Tip: After loosening the pin vice, use the tips of a pair of tweezers (in your free hand) to guard the barrel arbor from exiting the barrel when the pin vice is removed (in times like this you need an extra pair of hands).

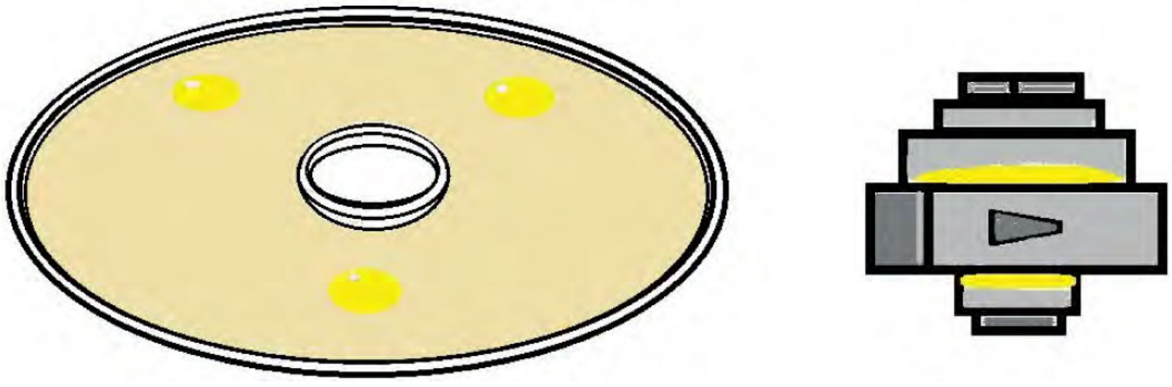


Diagram 12: Lubrication of the barrel and its arbor.

Apply some oil on the barrel arbor's bearing surface, on which the barrel cap rotates. As before, use a heavy grade oil (D5/HP1300/9020 or similar). Apply a slightly smaller amount of oil here as this bearing surface is slightly smaller.

Some watch repairers tend not to oil the barrel's bearing and insist that the oil/grease from the spring will eventually lubricate the barrel arbor. My personal feeling is that you cannot be certain how long that will take, therefore it is best to err on the side of caution.

I will cover oiling in greater detail later on, and at this point we are on a voyage of discovery and not servicing the watch. I am trying to save you the pain of handling the spring later on when I talk you through the cleaning process. Fitting a mainspring is a fiddly business for the beginner, and the less you handle it, the less chance there will be of it becoming damaged.

Fit and lubricate the barrel cap with three dots of grease on the inside surface. Remember that one side of the barrel cap has a lip round the edge and this is the inside surface! The barrel should still be on the bottom half of the barrel closing tool. You now need to slide the mating half of the tool over the barrel and its cap. Lift up the two parts and give it a little squeeze. All being well, you should hear a little click. This means that the cap is now fitted to the barrel. If you struggle fitting the barrel cap, this may be due to the fact that the barrel is an odd shape, making it hard to close in this manner.

It is possible to close it manually, so if you have not purchased a barrel closing tool, you can follow these steps: either wear finger cots or hold both the barrel and the cap between your fingers with a piece of tissue paper acting as a barrier. Hold half of the barrel and the cap between your index finger and thumb, making sure half of the cap is half clipped in place, then offer the visible part of the cap's outer edge up to a flat edge of table and push it a bit to twiddle the rest of the cap back on. You may have to rotate the barrel in small stages, keeping a constant tension on the barrel until it is fully clipped on.

'Check the End Float'

Now that the barrel cap is on you will have to check that there is sufficient end shake on the barrel arbor, or to use an engineering term that you might have heard of: 'Check the end float'. This is the play or movement of the barrel arbor inside the barrel. This is important, as the barrel cap may have been slightly distorted during removal and fitting. If there is no end shake on the barrel arbor the barrel and its arbor will bind, and this will hinder the smooth transmission of energy flowing through the train of gears. If the barrel arbor has too much end shake, this may cause the barrel to foul its mating gear or rub on the barrel bridge. The amount of end shake should be about .20mm, roughly the thickness of a medium-weight printer paper.

To test the end shake, take a pin vice and fit one end of the barrel arbor in its jaws and screw it up tight. Put the pin vice in your left hand. Lightly grasp the barrel by its teeth between your index finger and thumb of your right hand. Give the barrel and pin vice a light pull and push. You should be able to see and feel the end shake.

ADJUSTING A BARREL'S END SHAKE

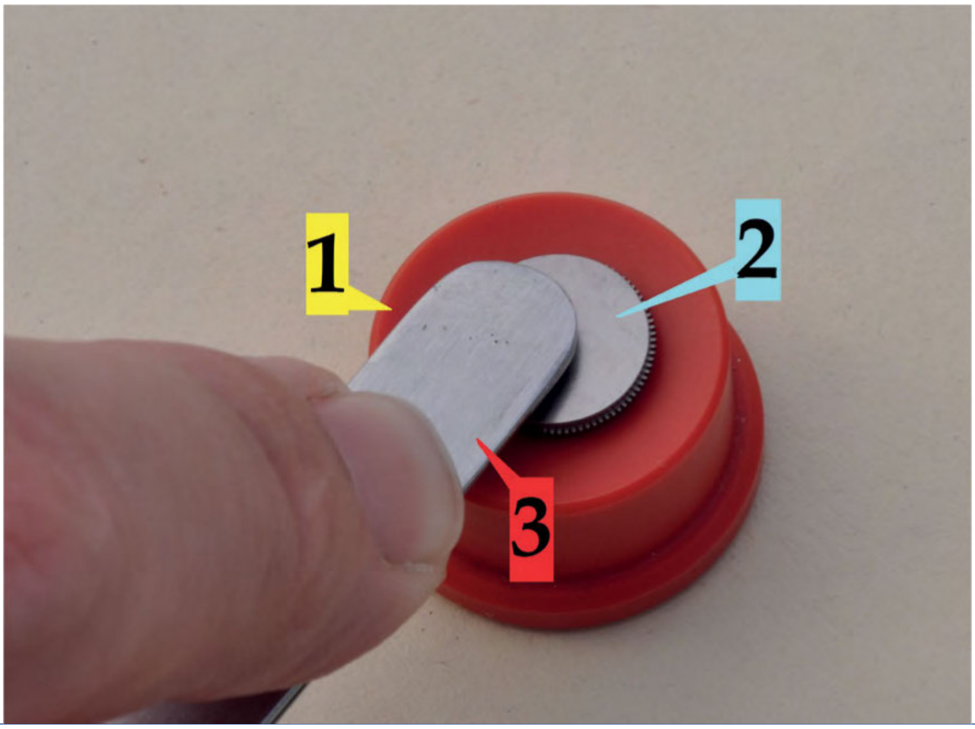


Fig. 116: Using the domed base of the barrel closing tool (1) to increase the end shake of the barrel arbor inside the barrel (2), by pushing the end of your tweezers (3) on top of the barrel arbor.

A barrel's end shake can only be adjusted with the Bergeon barrel closing tool or some type of barrel dolly. You need a tool with an inverted radial surface, with a hole in the centre.

If there is no end shake or too little, place the complete barrel on top of the tool with the barrel cap facing the bench. Using the back end of your rough tweezers (not your best pair), press on the barrel arbor so that it moves slightly inside the barrel. This will have the effect of dishing (curving) the cap slightly. Check the end shake in a pin vice as before.

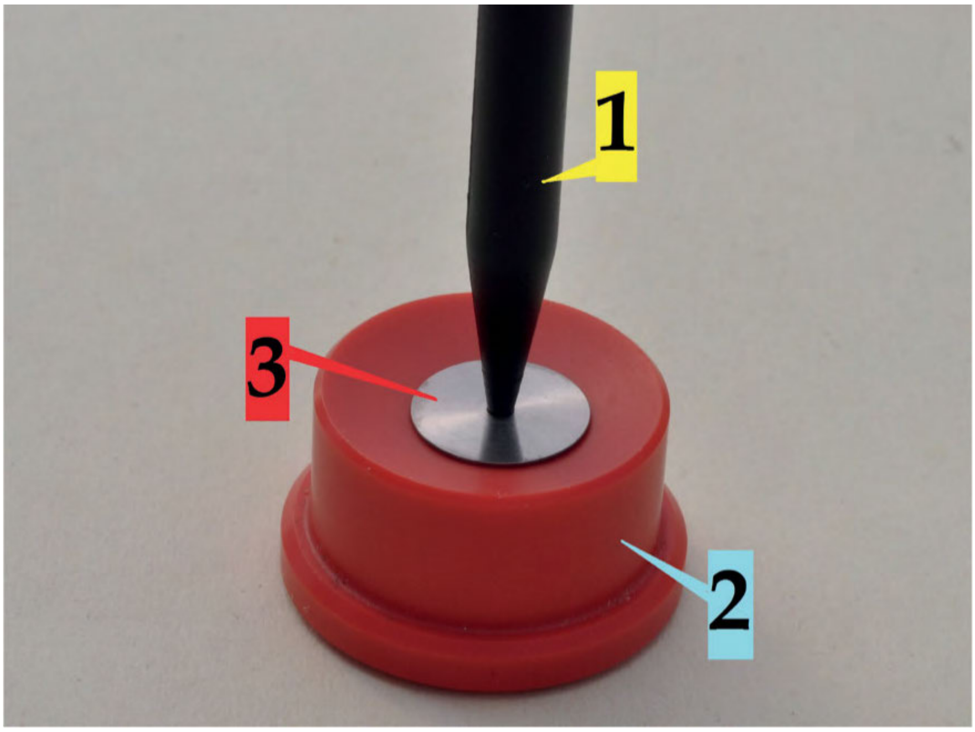


Fig. 117: Decreasing the end shake by doming the barrel cap (3), using the barrel closing tool base (2) and a watchmaker's probe (1).

If there is too much end shake the barrel's cap will have to be removed. This is done by placing the barrel on the rounded end of your tweezers, remembering to have the barrel oriented so that the end of the barrel arbor with the screw hole is facing down. Supporting the top of the barrel and pushing the teeth with a finger nail, you should hear a pop and the cap should be free. Place the cap on the tool and use the round end of your watch repairer's probe (or a sharpened piece of peg wood of a suitable diameter) to put this in the barrel cap's hole. If you apply light pressure you will see the cap flex, and this will have the result of dishing the cap in whatever direction you wish, to achieve the desired end shake.

20. ALTERNATIVE METHODS OF FITTING A MAINSPRING

USING AN ANTIQUE MAINSPRING WINDER

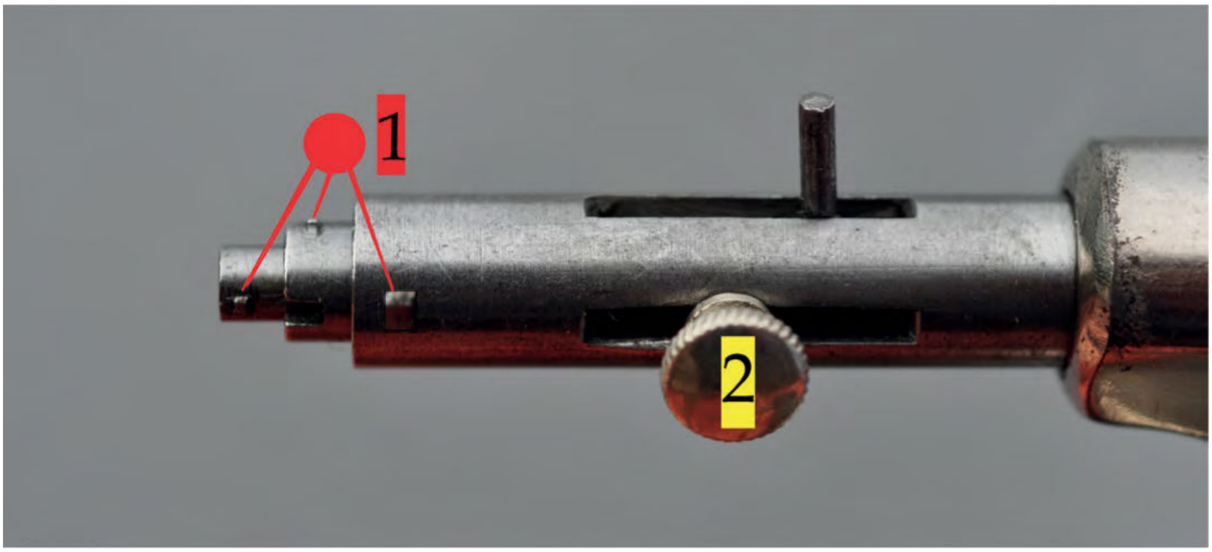


Fig. 118: An antique German mainspring winder, showing three different-sized hooks (1). Using the knob (2), the desired hook can be moved in or out.

An antique mainspring winder is a much cheaper option than the Swiss mainspring winder. It is much trickier to use, but you can fit just about any size of spring you like with it. I personally only ever use this tool to fit pocket watch springs. The only advantage this tool has is that you can remove the springs from the barrel as well. As far as I know they no longer make them, but there seems to be a good supply of second-hand ones on the internet, at a fraction of the price of a Swiss mainspring winder. The tool is held in the jaws of a vice, making it quite steady.

For safety, when using this tool I would recommend wearing leather finger cots (which can be bought from most jewellery tool suppliers or horological tool suppliers) on your index and forefinger, and a regular cot on your thumb. You may even wish to wear safety glasses. This is because the mainspring can be quite sharp, and may flick out at you.

Attach the centre of the spring to one of the hooks that fits the hole in the centre of the spring, and set the ratchet so that the crank handle rotates in a clockwise direction.

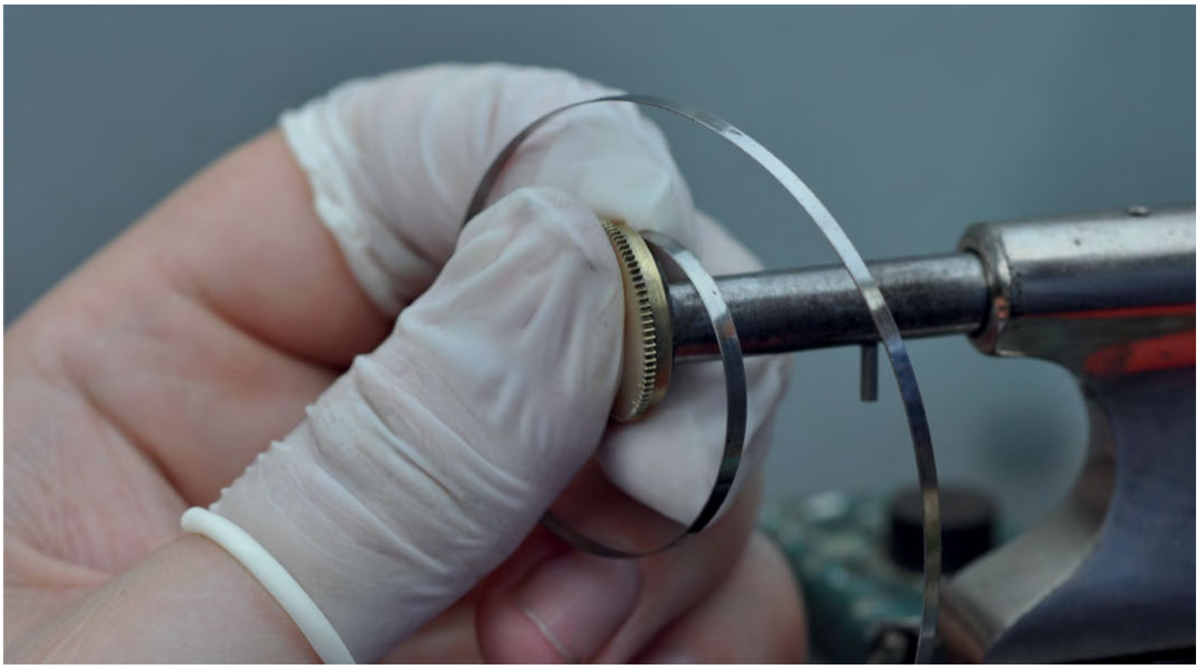


Fig. 119: Guiding the spring into the barrel using your index finger, as you rotate the crank handle.

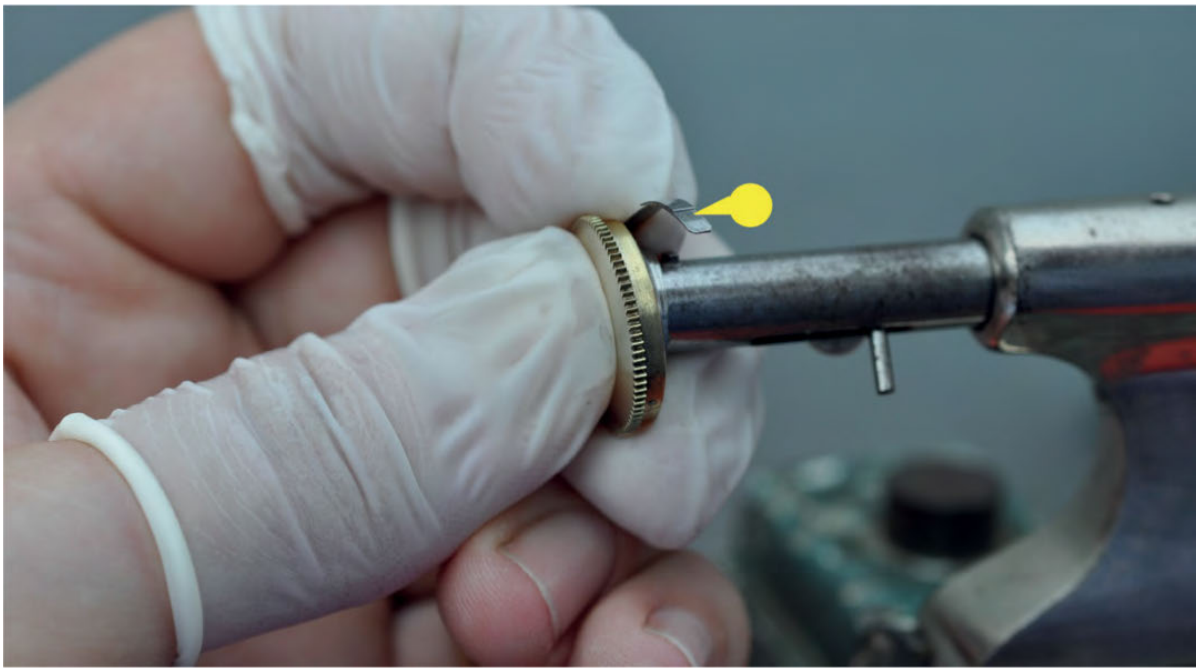


Fig. 120: Easing the spring's hook into the barrel. You may need to use a pair of stout tweezers.

Offer the barrel to the centre of the spring using your index finger to push the mainspring in the barrel, top and bottom, placing your thumb to hold the barrel in place. With your free hand, rotate the crank handle slowly and watch the spring being drawn into the barrel. When you get to the point where the hook is about to enter the barrel, you will probably have to use tweezers in your right hand to ease the hook into the barrel.

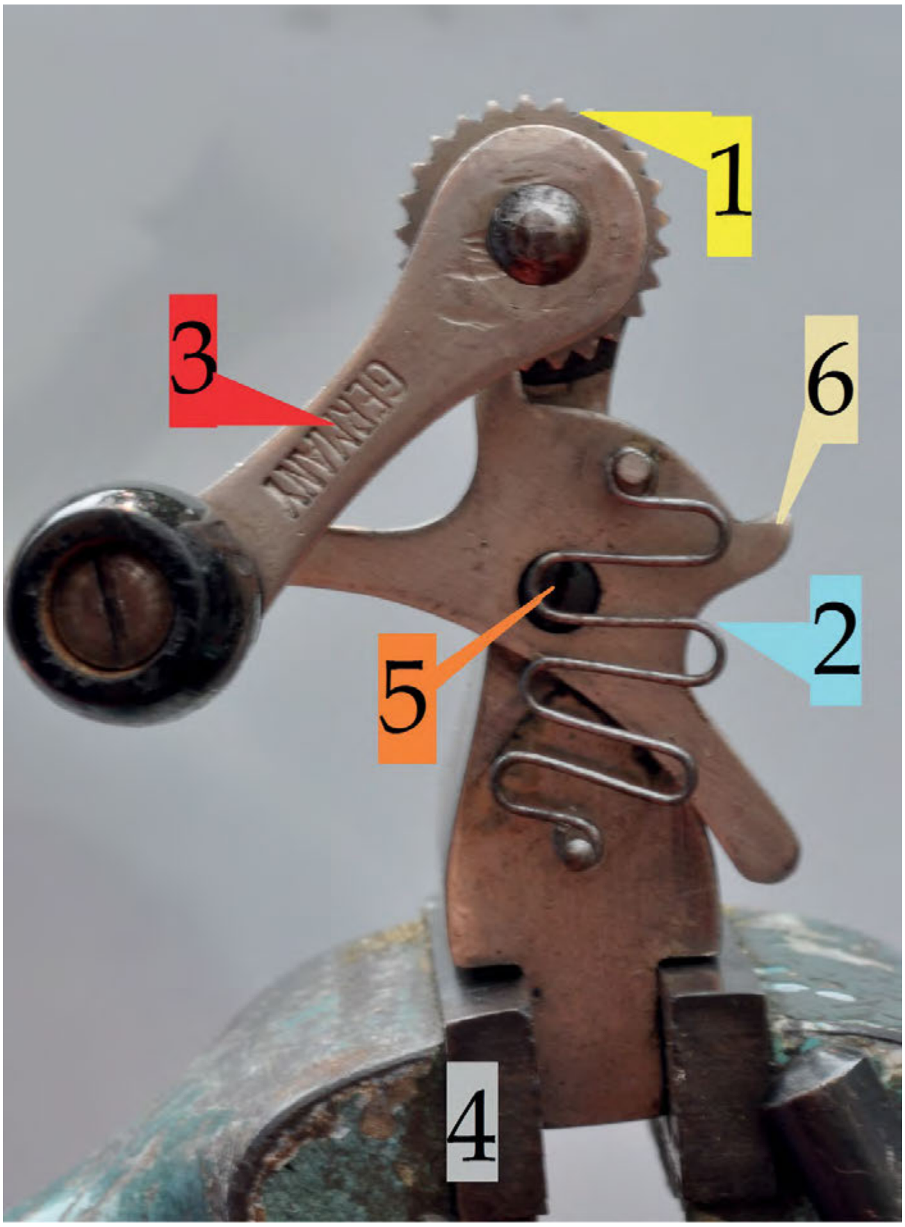


Fig. 121: Parts of the tool. 1: Ratchet wheel. 2: Click spring. 3: Crank handle. 4: Watchmaker's vice. 5: Click pivot point. 6: Double-sided click.

Once the hook is in the barrel you will have to let down the remaining energy in the spring. You can slowly let the barrel rotate in your fingers, or you rotate the crank handle a fraction of a turn and flick the ratchet to allow the crank handle to rotate in the opposite direction to let off the remaining energy in the spring.

FITTING A SPRING BY HAND

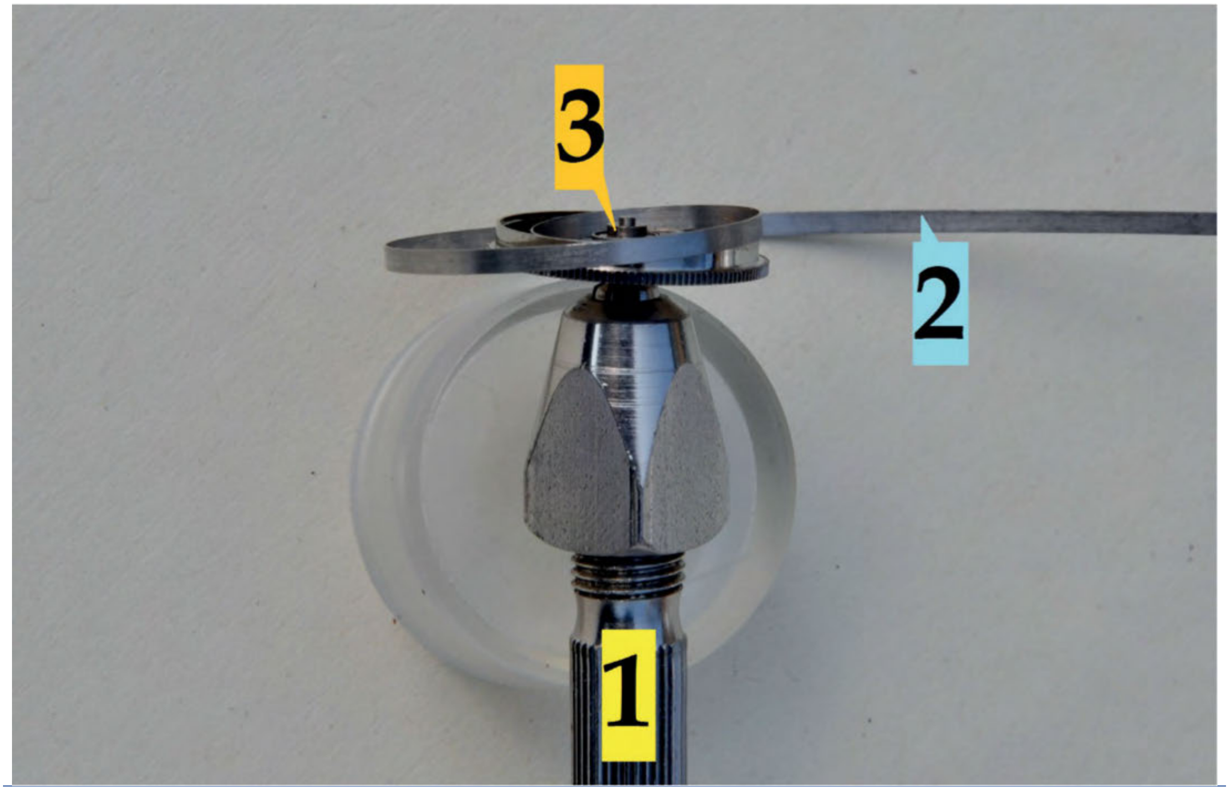


Fig. 122: Fitting a mainspring using a pin vice. 1: Pin vice. 2: Mainspring. 3: Barrel arbor.

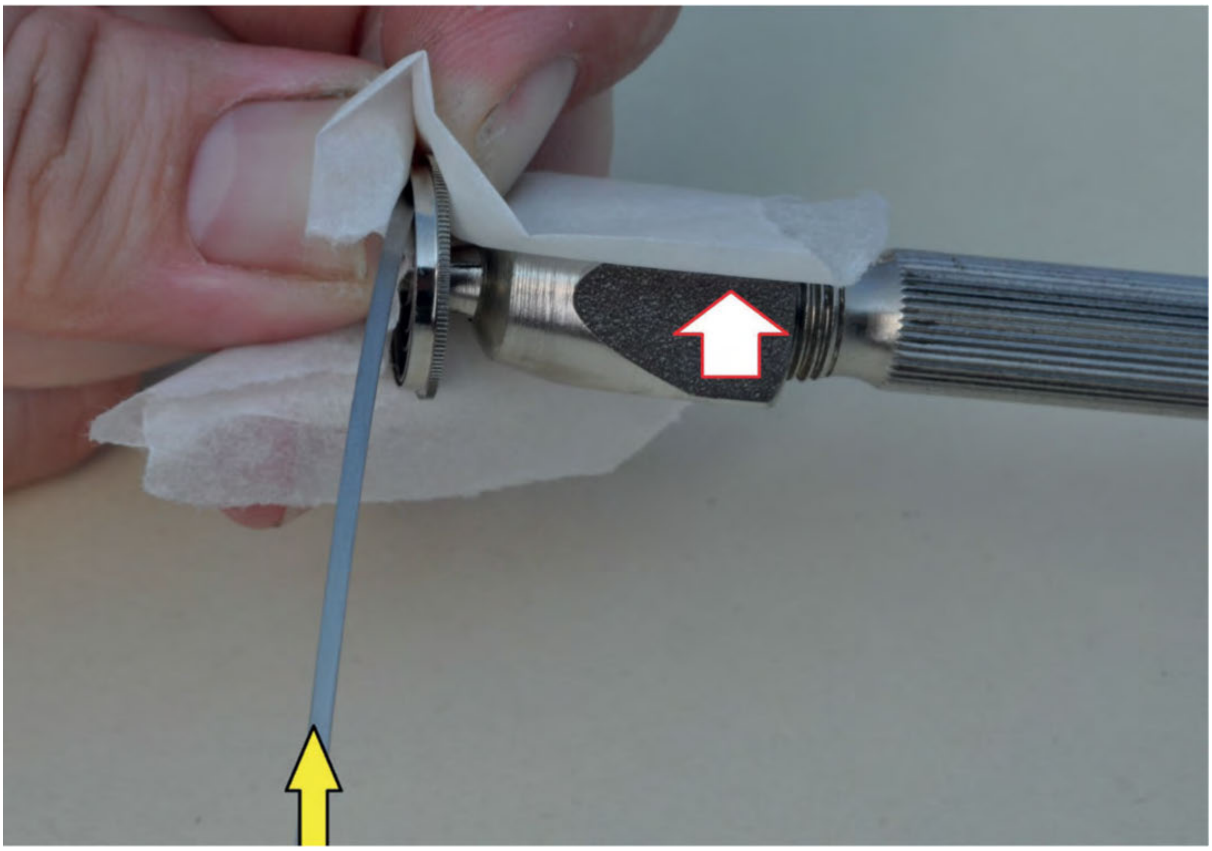


Fig. 123: Guiding the spring into the barrel using some watchmaker's tissue (as the pin vice is rotated).

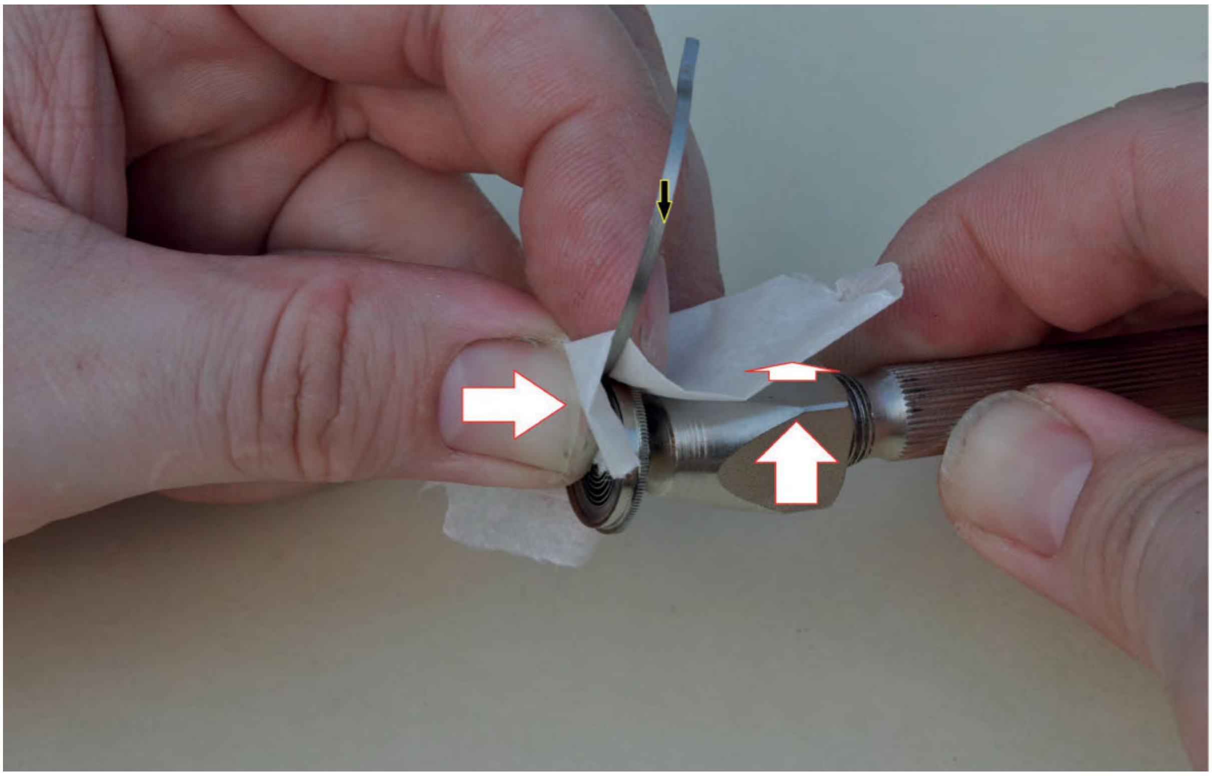


Fig. 124: Guiding the last inch of the spring into the barrel. (You will now be wishing you had three hands!)

Fitting a spring by hand is far from best practice, but needs must when you are starting out. My personal opinion is that if you don't have access to a mainspring winder, you would be better off leaving the spring well alone, unless it is broken.

To fit a spring by hand, you first fit the barrel arbor in the barrel, so that the end with the hole is facing the bench. It is nearly always fitted in this orientation. Lift up the barrel with the fitted arbor, and carefully fit a pin vice to the barrel arbor's end, which is now poking out of the bottom of the barrel (make sure the pin vice is nice and tight on the arbor).

Tip: For safety I would recommend using leather finger cots at this point.

Hold the pin vice in your right hand, and hold the barrel and spring in your left; place your left-hand index finger on top of the barrel, with your forefingers supporting the back of the barrel, and use your thumb to act as a guide as you push the mainspring into the barrel, acting as a barrel cap.

With your right hand, rotate the pin vice in a clockwise direction: this will slowly pull the spring back inside the barrel. If you are fitting a modern reverse curve or ‘S’-shaped spring, you will have to put your little finger in the middle of the reversed curve’s coils, to stop them from getting tangled up as the spring is pulled back into the barrel.

If you are finding it hard to rotate the pin vice, try not to pinch the barrel and spring so much; you will soon notice that the spring slips into the barrel a lot more quickly.

To help prevent the hook of the spring from being damaged as it enters the barrel, you will probably have to use a pair of tweezers in your right hand and ease the hook into the barrel. You will, however, have to juggle the barrel and the pin vice in your left hand, at the same time holding the spring in place.

Once the hook is in the barrel you will have to let down the remaining energy in the spring. To do this you can slowly rotate the pin vice in your fingers, and proceed to fit the barrel’s cap. Remember to grease the inside of the barrel and the cap with three dots of 8200 Moebius grease the size of the barrel arbor’s pivot, and oil the barrel arbor’s two larger shoulders with D5/HP1300/9020 before fitting it into the watch.

This method is very much like using the antique mainspring winder and will take a little practice. But once you get the hang of this, it’s a very easy method of fitting a mainspring, even automatic watch springs, without distorting them.

REFITTING THE BARREL INTO THE MOVEMENT

Before fitting the barrel, it is normal to oil the barrel arbor’s pivots with a heavy oil (read more about this in the oiling section).Tuck the barrel into the movement under the centre wheel: if you have the barrel the right way round, its teeth should be on the top, and the hole in the barrel arbor should also be visible. If you removed the bolt screw, remember to fit it before fitting the barrel bridge (this is the only screw to have a smooth middle section).

Place the barrel bridge over the top of the barrel, making sure to locate the steady pins of the bridge, and also making sure the centre wheel’s top pivot locates into its corresponding jewel/hole in the plate. If the bridge is flush to the base plate, refit the three screws that hold it down.

Remember that in some watches, one of the three screws is half the length of the others, and this is normally fitted either side of the bolt screw. When removing any screws it is always a good idea to take note of any differences in length or shape.

Alternatively, as you remove any screws, take a picture of them next to their respective holes on the removed bridge. As you become accustomed to certain models, you will inherently know where the screws fit.

Once the bridge is fitted, put the ratchet wheel on its square, remembering that the ‘pretty’ side should be showing. Sometimes there may also be a recess in the centre of the ratchet wheel. This also normally indicates that this is the top of the wheel, as the ratchet-wheel screw head fits into the recess. Secure the ratchet wheel with its screw: this is always the largest screw in the watch.

If the stem isn’t fitted, refit it and proceed to wind up the watch. All being well, the watch should leap into life after a couple of winds on the spring.

21. THE ESCAPEMENT AND THE BALANCE WHEEL

THE ESCAPEMENT IN BASIC TERMS

If we look at the watch thus far, you have a mainspring trying to uncoil, which transmits its energy though the gear train (gearbox, if you like). If there was nothing to stop and control this release of energy, the gear train would run at full speed, exhausting the energy of the spring in less than sixty seconds, just like a wind-up toy car. This is fine, as long as you don't mind winding up your watch every sixty seconds!

With this in mind, we therefore need a device to time and release the gear train, and this comes in the form of the balance wheel. This is a rimmed wheel, with typically two or three spokes mounted on a pivoted arbor. A coiled spring is fixed to the centre, on its arbor. The other end of the spring is fixed to the balance cock. You will see them when you remove the balance from your watch shortly (see next section).

With no power on the mainspring, you can give the watch a small shake: the balance wheel will start to oscillate, and it requires only a very tiny amount of energy to keep it oscillating. For the balance wheel to be a regulatory system we need to keep it constantly oscillating. Think along the lines of a child on a playground swing, swinging their legs in and out to keep the swing in motion. The device we need is called the *escapement*, and its prime function is to give a small push to the balance wheel. It also enables the indexing (moving along a tooth) of the escape wheel to allow the hands of the watch to move at a governed speed. This energy comes from one of the escape wheel teeth pushing one of the two pallet stones.

These two stones are attached to a T-shaped lever, with the pallet stones projecting from the top of the T. When the pallet stones are pushed by the escape wheel, this causes the lever to move left or right, depending on the direction in which the balance wheel is oscillating. Once in motion, the balance wheel moves the lever, and the lever unlocks the escapement. The lever connects with the balance wheel via the impulse pin on the roller, and gives the balance wheel a push. At the point the push (impulse) is over, the other pallet will lock the gear train. The balance wheel is then made to move on its supplementary arc until energy stored in the balance spring overcomes that of the balance wheel to reverse it.

With every swing left or right of the balance wheel there is a transference of energy, which can be heard when you put you watch to your ear: tick-tick-tick-tick. In fact the ticking is the sound of the next tooth of the escape wheel being locked just after impulse – the impulse is an almost silent noise in between – when the energy has passed from the mainspring to the balance wheel. Secondly (and more importantly) the gear train has indexed a tiny amount, thus the hands have also moved.

On the balance's reverse swing, its impulse pin on the roller will make contact with the pallet's lever, moving the lever to unlock the escape wheel, giving an impulse in the other direction.

This will all become much clearer as you move through this book, particularly the next few chapters.

The parts of the Swiss lever escapement are illustrated in Figs 125 to 130.

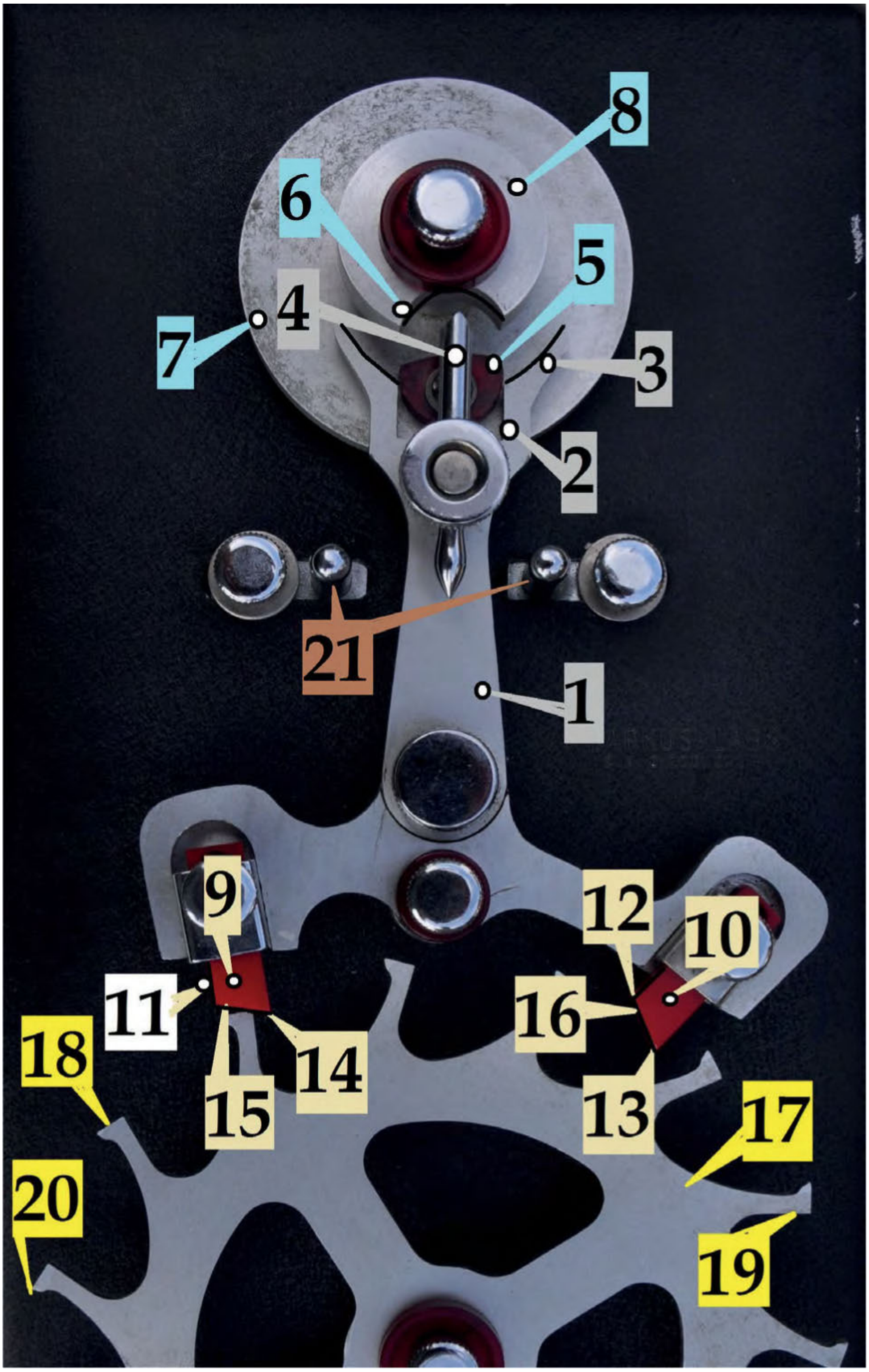

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Fig. 125: Parts of the Swiss lever escapement. 1: Lever. 2: Notch. 3: Horns. 4: Dart or guard pin. 5: Impulse pin or jewel. 6: Roller-crescent or notch. 7: Roller table. 8: Safety roller. 9: Entry pallet jewel. 10: Exit pallet jewel. 11: Entry locking face. 12: Exit locking face. 13: Exit discharge corner. 14: Entry discharge corner. 15: Entry impulse plane. 16: Exit impulse plane. 17: Escape wheel. 18: Tooth impulse plane. 19: Locking face of a tooth. 20: Discharge corner of a tooth. 21: Pair of banking pins.

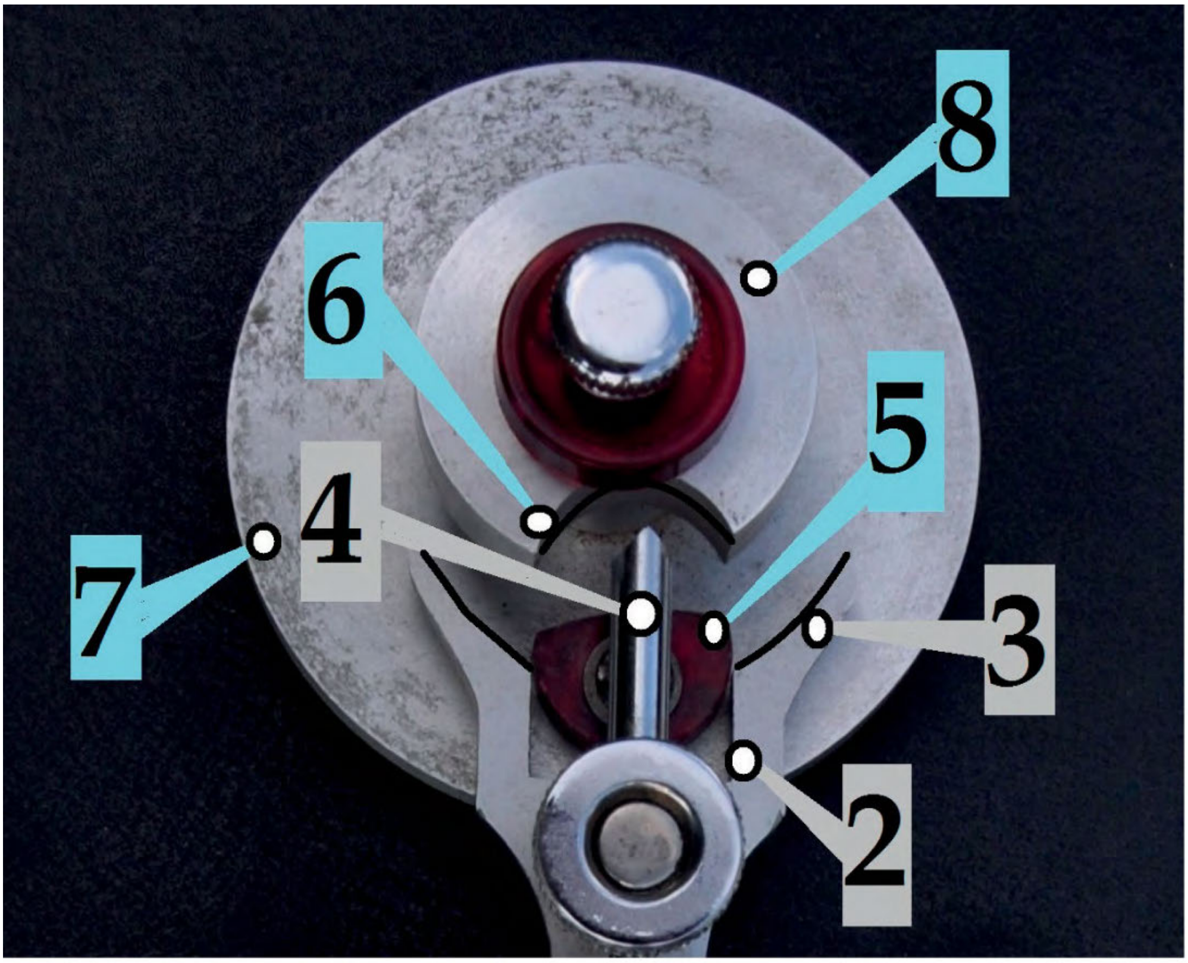


Fig. 126: A closer look at the roller. 2: Notch. 3: Horns. 4: Dart or guard pin. 5: Impulse pin or jewel. 6: Roller crescent or notch. 7: Roller table. 8: Safety roller.

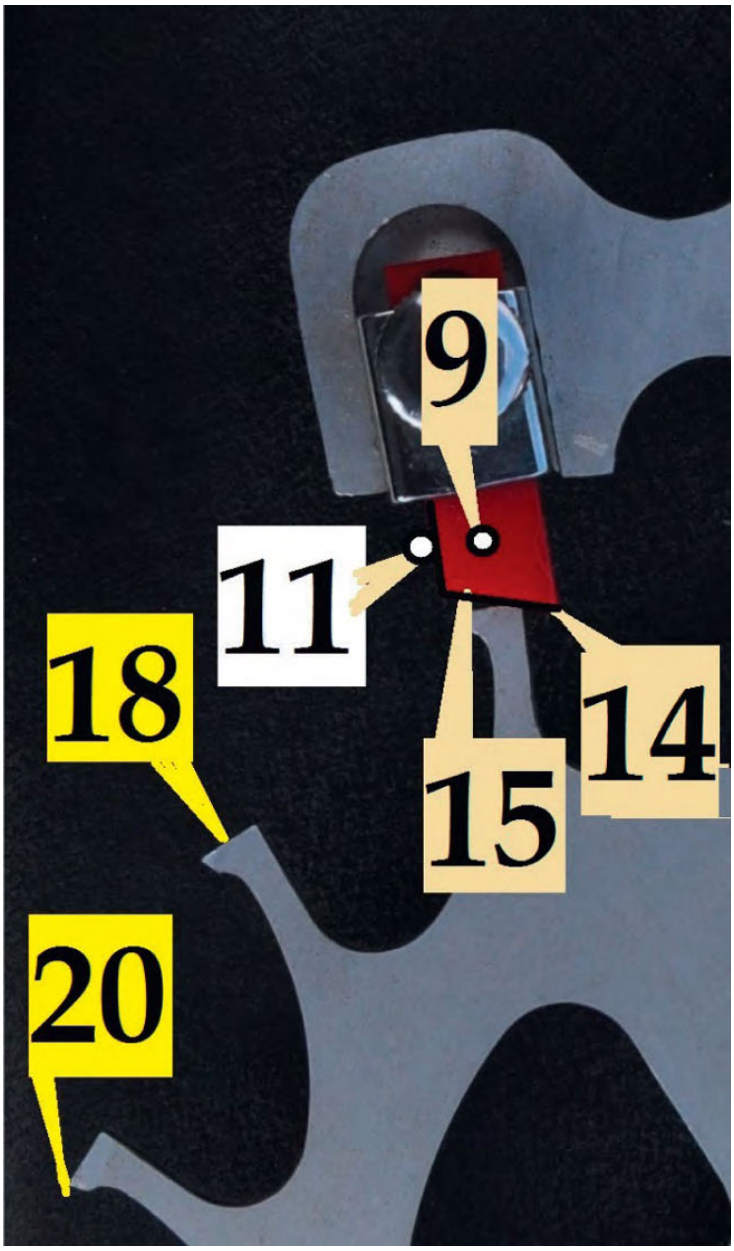


Fig. 127: A closer look at the entry pallet and escape wheel. 9: Entry pallet jewel. 11: Locking face. 14: Discharge corner. 15: Impulse plane. 18: Escape wheel impulse plan. 20: Escape wheel discharge corner.

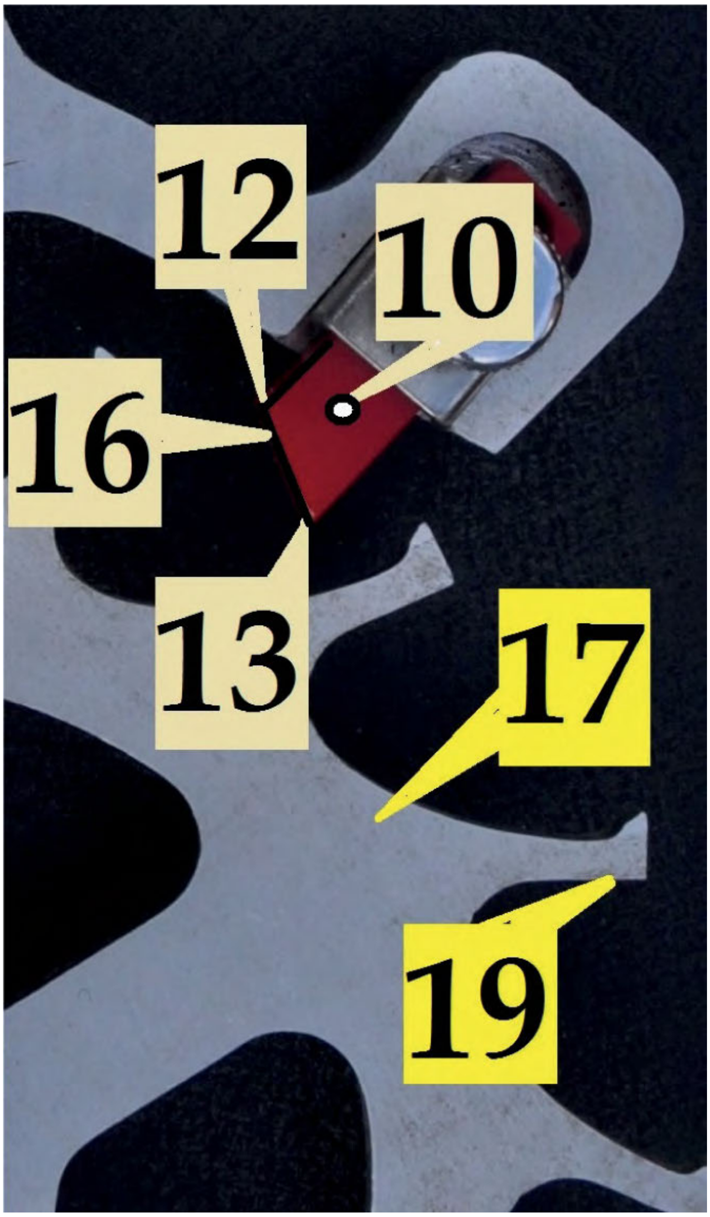


Fig. 128: A closer look at the exit pallet and escape wheel. 10: Exit pallet. 12: Locking face. 13: Discharge corner. 16: Impulse plane. 19: Escape wheel locking face.

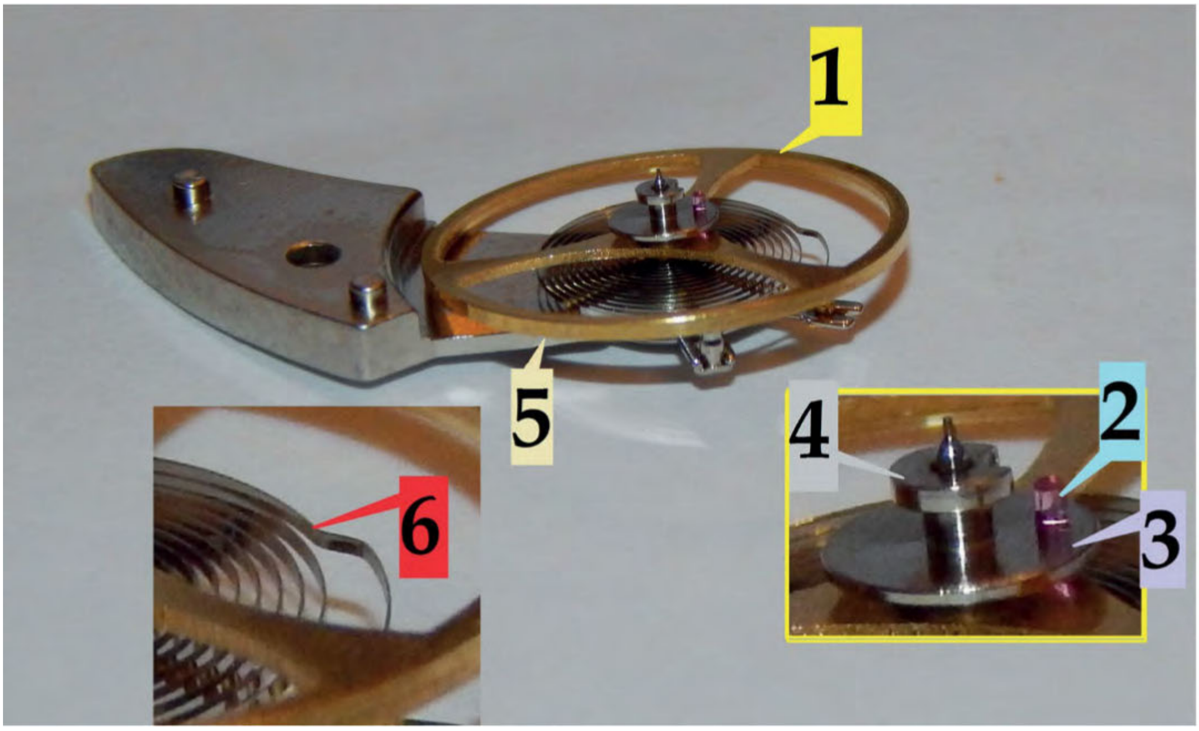


Fig. 129: Balance assembly. 1: Balance wheel. 2: Impulse pin. 3: Roller table. 4: Safety roller. 5: Balance cock. 6: Balance spring.

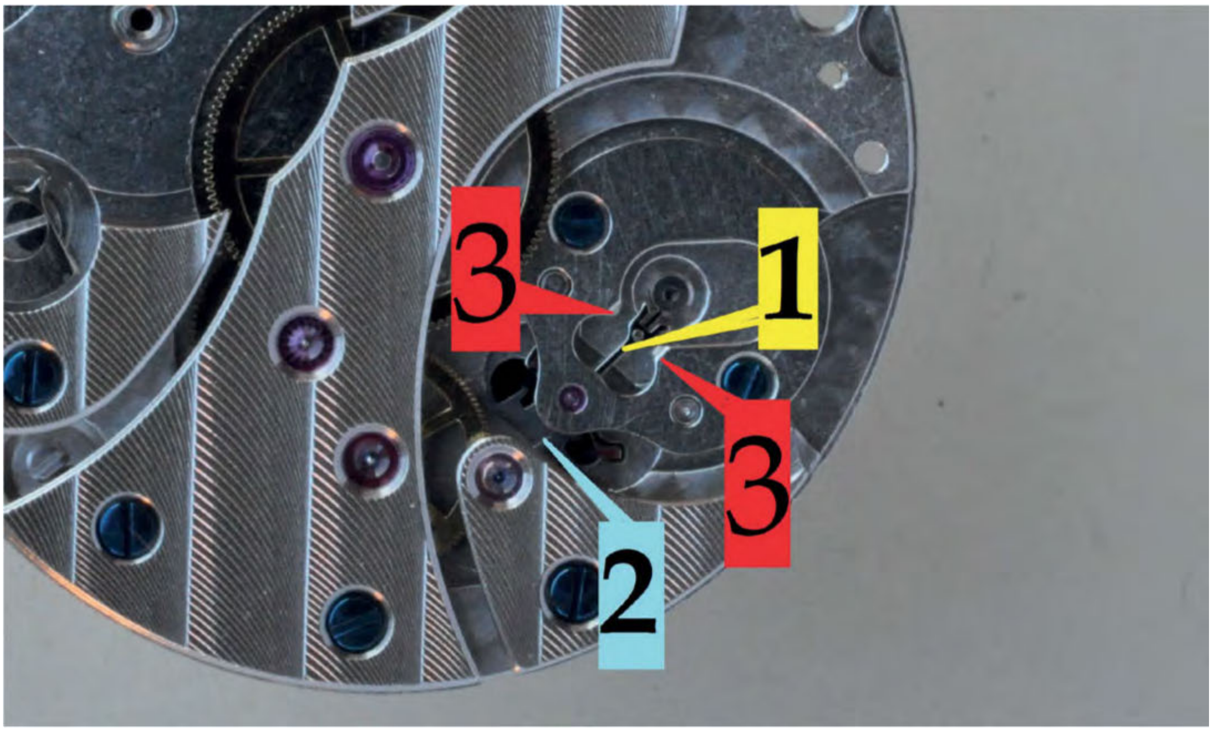


Fig. 130: The location of the pallets (1), escape wheel (2), and banking pins (3) inside the watch.

REMOVING THE BALANCE WHEEL

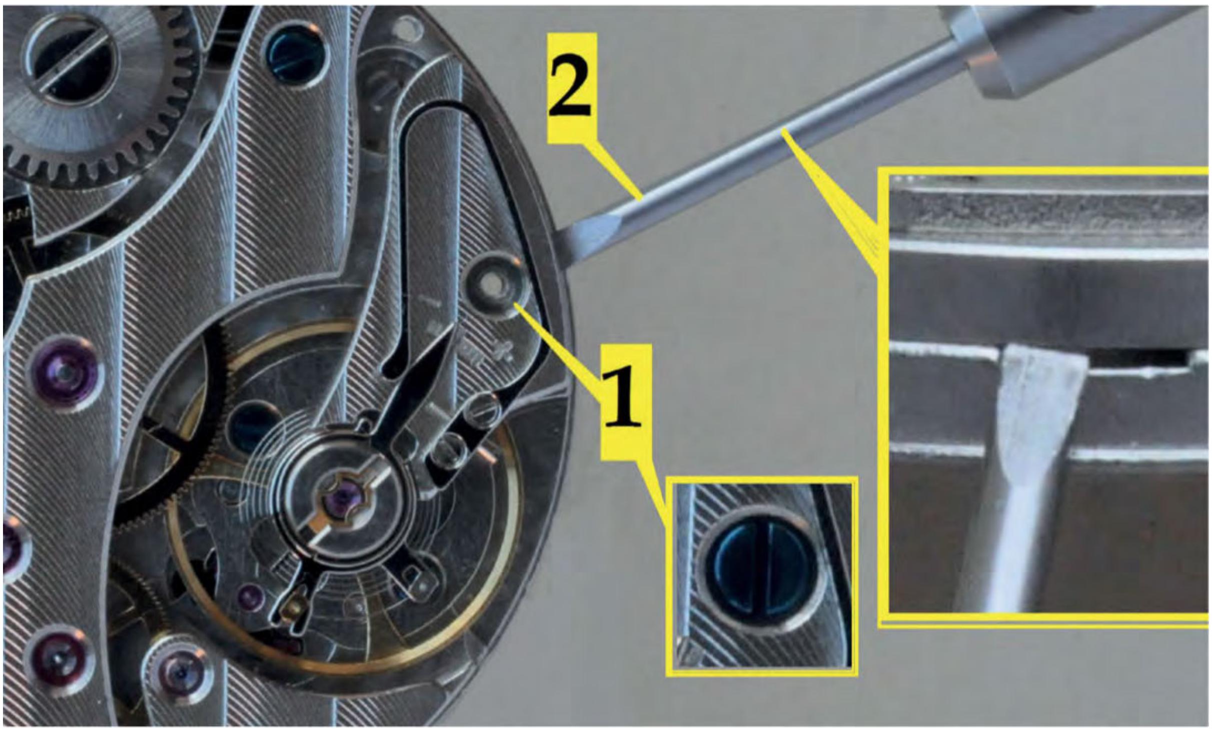


Fig. 131: Removing the balance assembly. Remove the screw (1); insert a screwdriver into the slot to lightly prize up the balance cock (2).

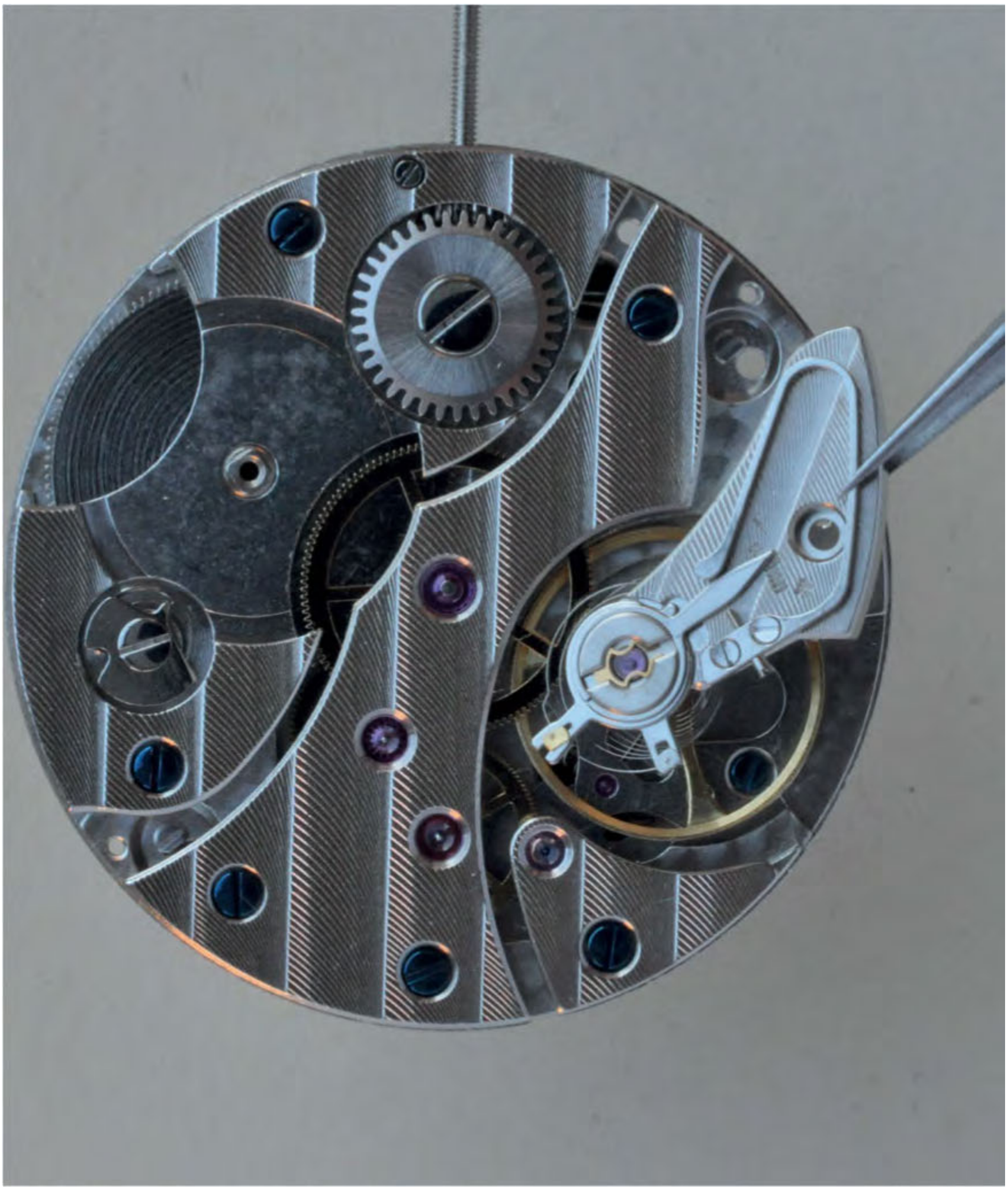


Fig. 132: Lift up the balance cock.

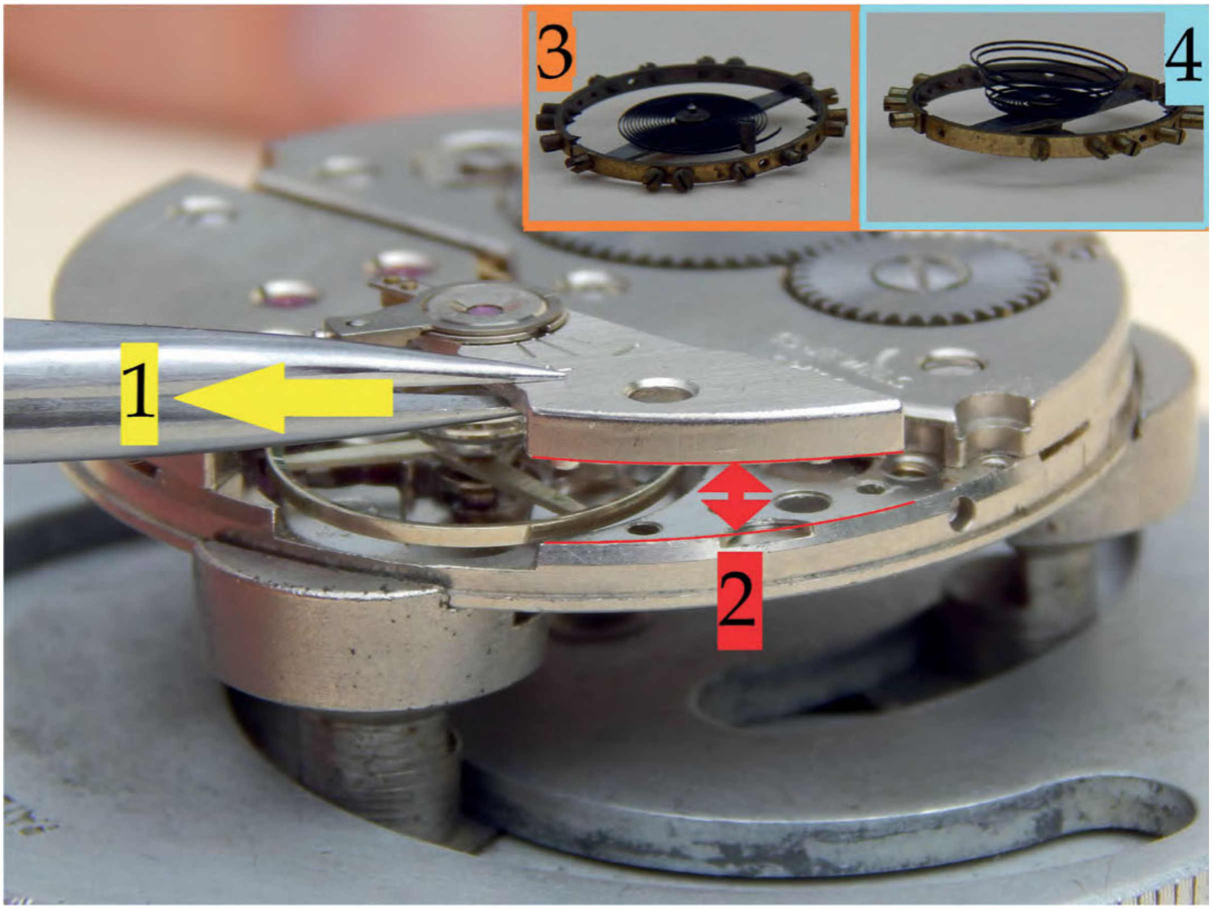


Fig. 133: When lifting the balance cock with your tweezers (1) never exceed the height (2) as indicated in the picture; if you do so, this will stretch the balance spring out of shape. 3: What a good spring should look like when removed from the balance cock. 4: A damaged spring that has been stretched.

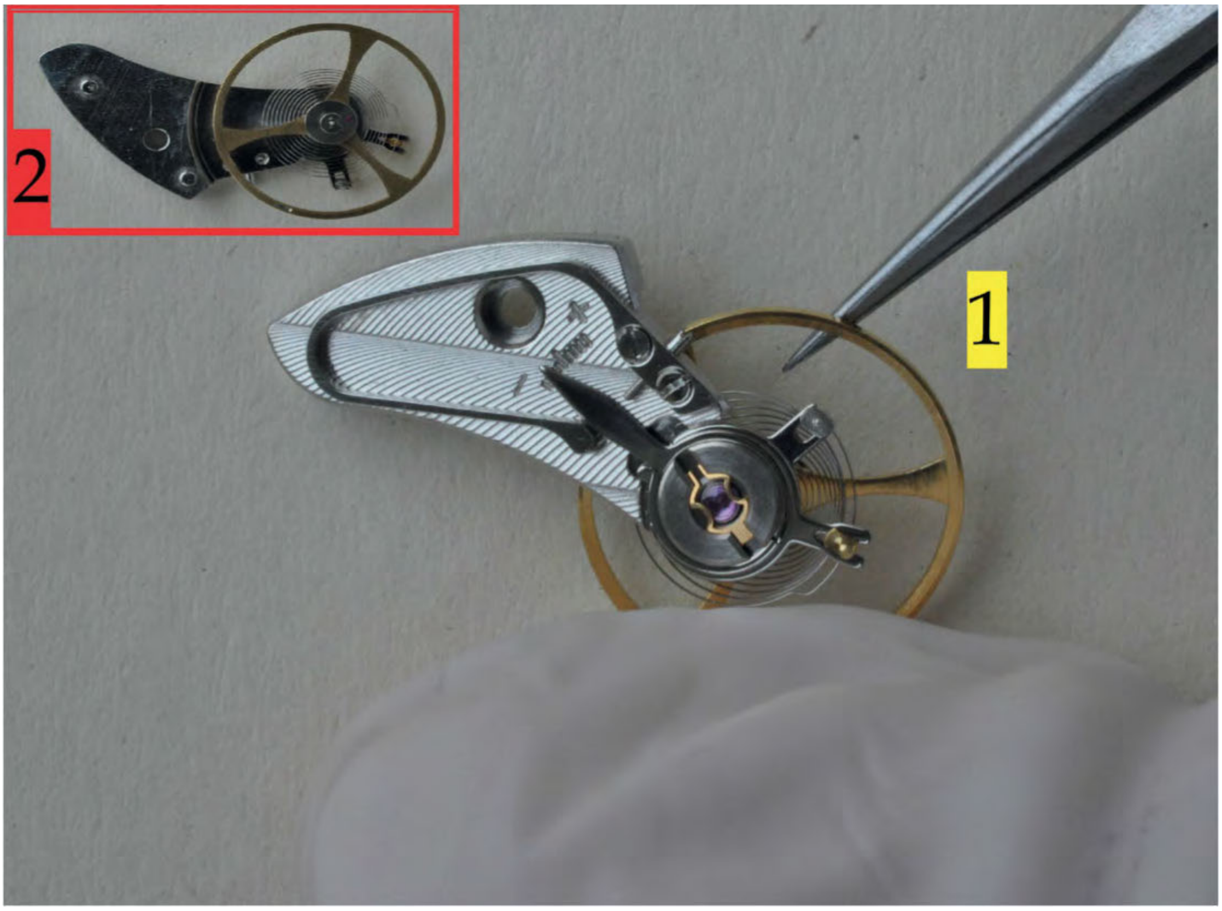


Fig. 134: 1: Turning over the balance assembly using a finger and your tweezers. 2: A turned-over balance assembly.

To look at the escapement you will first have to remove the balance wheel and its cock.

First, remove the screw that holds the balance cock to the main plate. If you look at the fatter end of the balance cock you will see a little slot that has been cut into the balance cock. Insert a screwdriver blade that is approximately the same size into the slot, and lever up the cock. As the cock is still fixed firmly to the plate by two steady pins, this will help loosen their grip on the main plate.

To lift out the balance, you will have to use your tweezers to grasp the fatter part of the balance cock (as shown in Figs 132 and 133), taking care not to grab the balance wheel itself as you will most definitely damage it.

Lift up the balance cock about a centimetre above its main plate, and hold it there for a second, allowing the balance's spring to support the balance wheel's weight. Surprisingly the balance spring is capable of taking the weight of the balance, and its elasticity will return it to its original shape, so you shouldn’t damage it if you are careful not to stretch it too much. You will soon know if you have overstretched it, as it will look like a slinky. Do not be tempted later to lift the balance wheel up in order to lift the balance cock: only ever lift the balance wheel by the balance cock.

As you lift the balance cock clear from the watch, you will also have to tease the balance wheel clear of the centre wheel (the big, gold-coloured wheel in the middle), as the balance wheel sits partially underneath it. To free the balance wheel, move the balance cock towards you about a centimetre, carefully maintaining its height above the movement. Next, you will have to give your levitating hand a micro shake (like a slightly shaky hand) to help the balance break free from the movement (just to be clear, your hand should move no more than a few millimetres during this micro shake, and be mindful not to damage the balance spring by overstretching it).

Once the balance wheel is free from the movement, lay it on the bench, almost as if it were going to be put back into the watch. Using the tips of your tweezers on the underside of the balance wheel, slowly turn the balance and its cock over, moving them as if they were one part, so that it is now lying upside-down (as shown in Fig. 134). This will hopefully prevent the balance’s pivot from being bent during storage.

Now that the balance wheel is upside-down, you will clearly see the roller on the underside of the balance and its parts. The roller is a small part of the escapement. It is here that the energy from the escapement is transferred to the balance wheel, and also where the balance wheel unlocks the escapement.

22. THE ACTION OF THE LEVER ESCAPEMENT

The complete action of the lever escapement can be broken down into six basic stages:

Unlock: Freeing of the gear train leading to impulse.

Recoil: Movement of the escape wheel during unlocking.

Impulse: The push given to a pallet stone, in turn moving the lever ultimately to transfer energy to the balance wheel to keep it vibrating.

Drop: Free motion of the escape wheel after impulse has taken place and before locking the next tooth.

Lock: Holding of the escape wheel until impulse is needed.

Draw: The escape wheel draws the pallet half a degree to keep the guard pin clear of the roller.

Run to banking: The action of the pallets striking the banking pins.

The action of the escapement is as follows – note that the following pictures show the escapement *from below*, to show the movement more clearly.

The escape wheel is held *locked* by the entry pallet on its locking face. The balance wheel has rotated anticlockwise, causing the balance spring to unwind.

The balance wheel is near its natural rest state or the zero line of the escapement, but has inertia keeping it in motion. The impulse pin on the roller has passed the horns of the pallets and has struck its notch. The stored energy in the balance wheel moves the pallet lever to the right with the aid of the impulse pin, which is fixed to the roller. This is the beginning of the escapement unlocking the escape wheel tooth. As the lever rocks to the right, its pallet pulls out of its locked position and forces the escape wheel to recoil. This recoil is so small you can’t see it with the human eye.

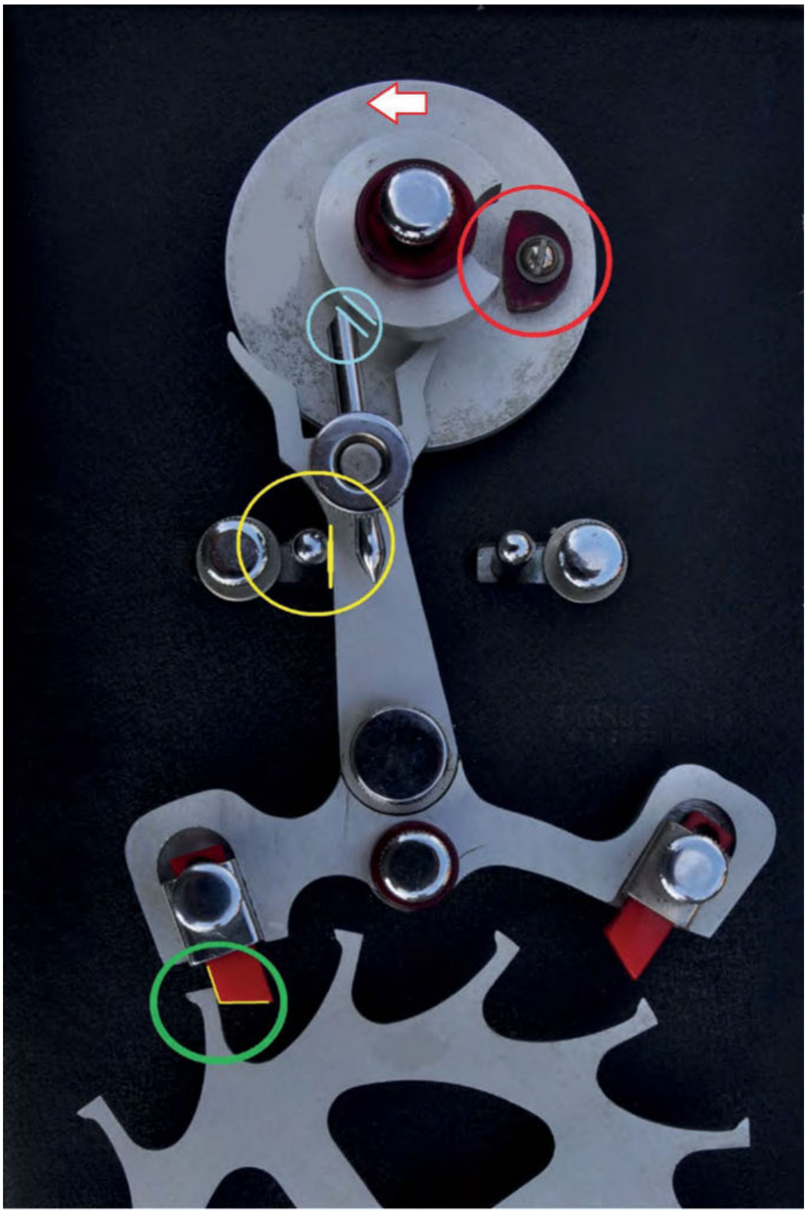


Fig. 135: Escapement locked on the entry pallet, with the balance swinging anticlockwise.

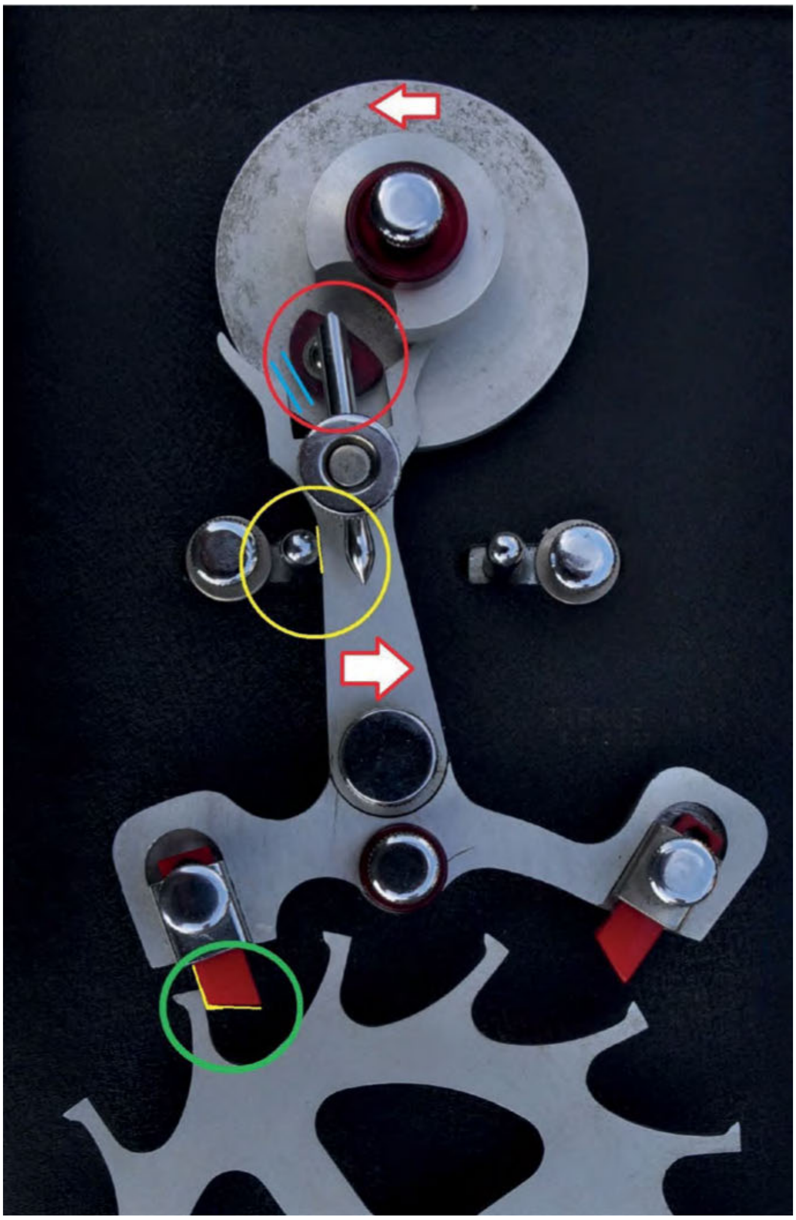


Fig. 136: Impulse pin entering the pallet notch.

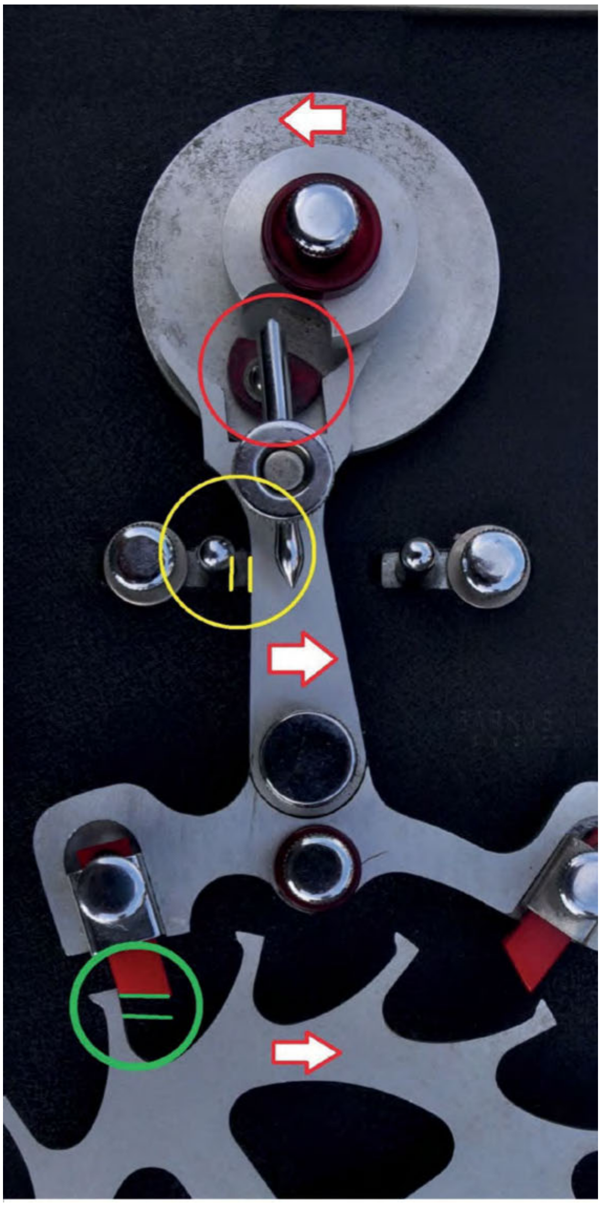


Fig. 137: Unlocking the entry pallet.

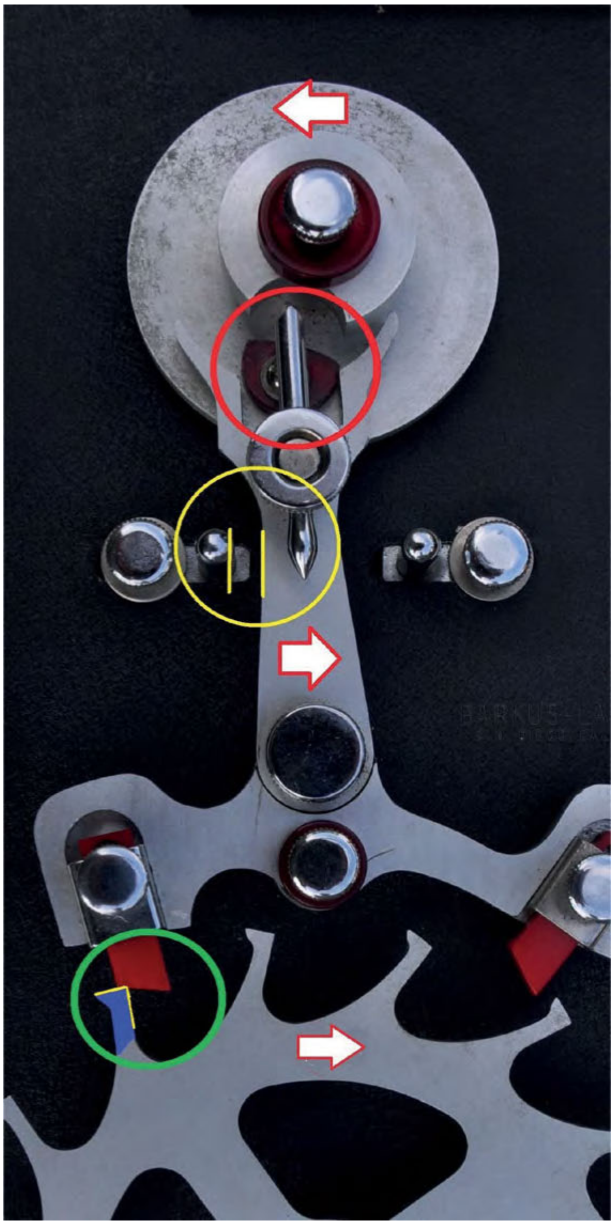


Fig. 138: Impulse being given to the entry pallet.

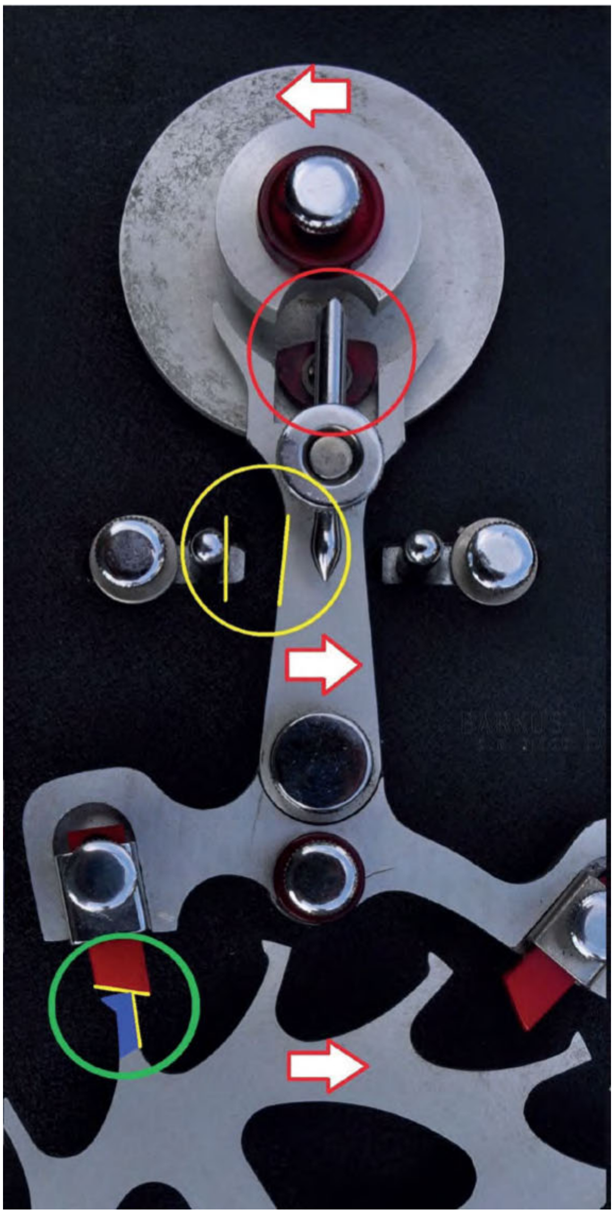


Fig. 139: The balance wheel continues to travel anticlockwise, and impulse continues to be given to the pallets.

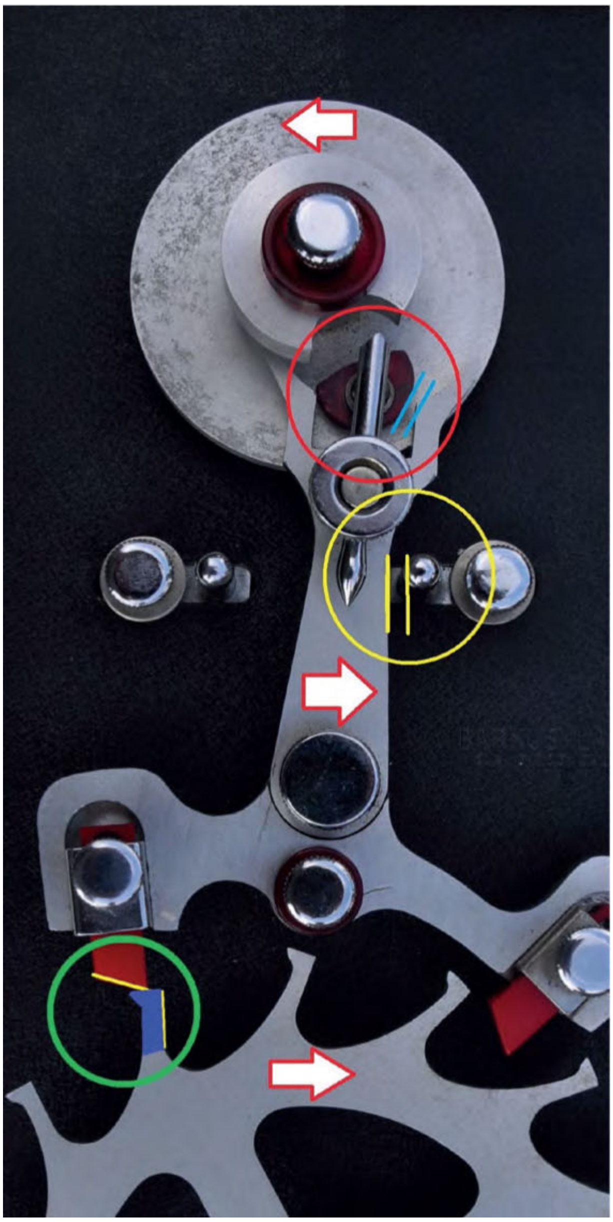


Fig. 140: Impulse continues. The balance is being given a push (impulse), and the impulse pin is about to exit the pallet notch.

As the lever starts to rock to the right (at this point the lever is being driven by the balance wheel), the locking face of the entry pallet slides up the locking face of the escape wheel. When the entry pallet reaches the summit of the escape wheel tooth (the discharge corner), this is the point of *unlocking*. The locked tooth is released, and it starts to push on the impulse plane of the entry pallet stone. This is the beginning of impulse being given to the entry pallet.

As the escape wheel tooth continues to slide along the impulse plane, it causes the lever to continue moving to the right. This is also the point where the energy from the gear train is transferred to the balance wheel. Instead of the balance wheel driving the pallet during unlocking, the pallet lever is driving the balance wheel. The fork end of the lever is now pushing the impulse pin, to maintain its oscillation.

The escape wheel tooth eventually slides off the impulse plane of the pallet stone, ending impulse. The escape wheel continues to travel in an anticlockwise direction. The impulse pin has passed the zero line of the escapement and is only just in contact with the pallet's notch. The escape wheel is in free motion (known as *drop*). The escape wheel will continue to rotate freely, until another tooth *locks* on to the opposite pallet stone's locking face (known as the 'exit' stone).

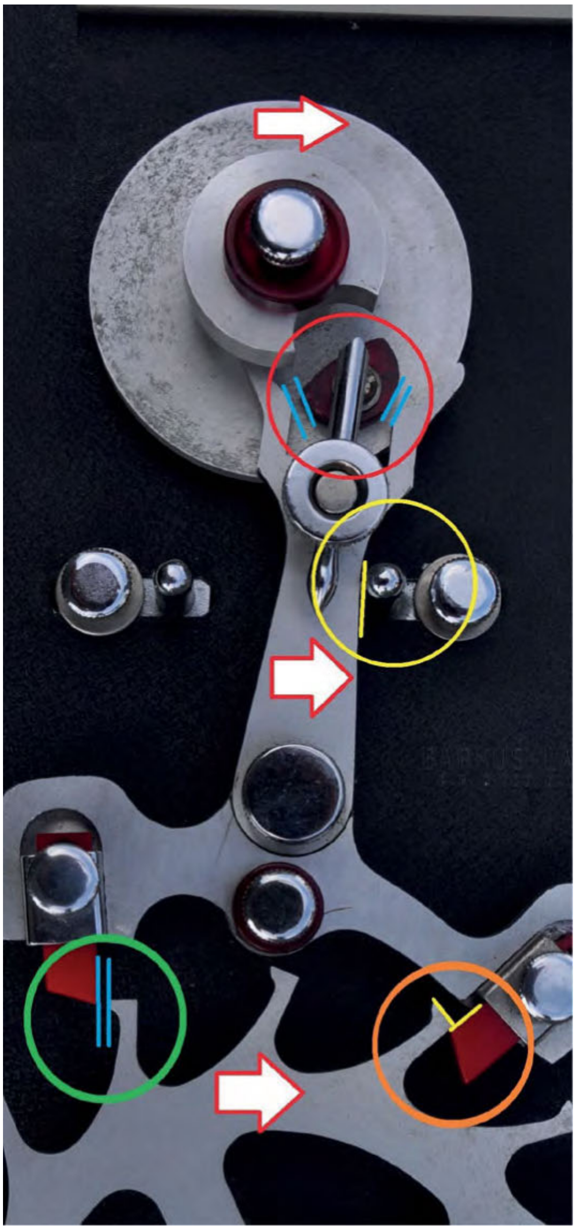


Fig. 141: Impulse ends. The escape wheel tooth drops off the pallet, and a tooth locks on to the exit pallet. The balance swings under its own momentum.

The escape wheel *draws* the pallet stone in towards its centre, causing the pallet lever to strike the banking pin (*run to banking*).This is caused because the pallet's locking faces have been angled to ensure the continued sliding of the pallet stone along the escape wheel's locking face. This movement between the two is known as *draw*. The total depth of lock is normally about one third of the impulse face of the pallet stone.

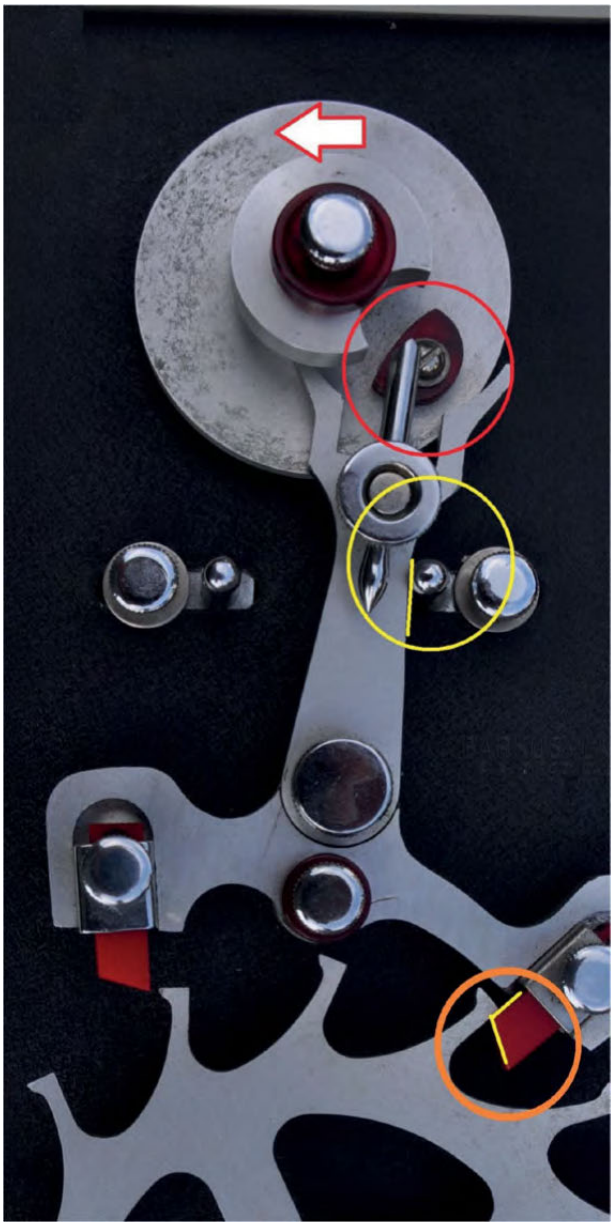


Fig. 142: The exit pallet is drawn into the escape wheel, and the lever strikes the banking pin.

The impulse pin eventually exits the pallet notch and continues its swing to the right with its burst of energy.

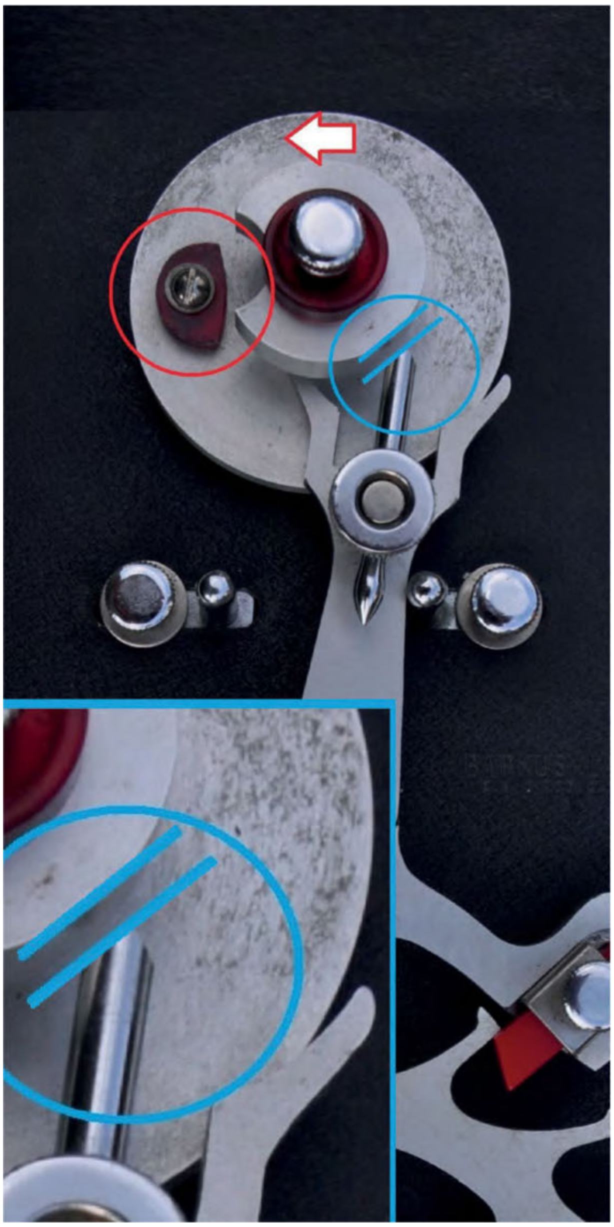


Fig. 143: The balance nears the end of its swing in a clockwise direction. The balance spring's stored energy starts to reverse the balance in the opposite direction. Note the clearance of the guard pin in relation to that of the safety roller.

This inertia of the balance wheel is soon overcome by the tension of the balance spring. A reverse in direction soon takes place, and the balance wheel swings back in the opposite direction (clockwise). The balance wheel returns back towards the pallets. The impulse pin re-enters the notch of the pallet lever, this time from the opposite side, and strikes its notch. Now, the inertia of the balance wheel is moving the pallet lever to the left. The escape wheel recoils a small amount (due to the action of draw) as the escape wheel is unlocked.

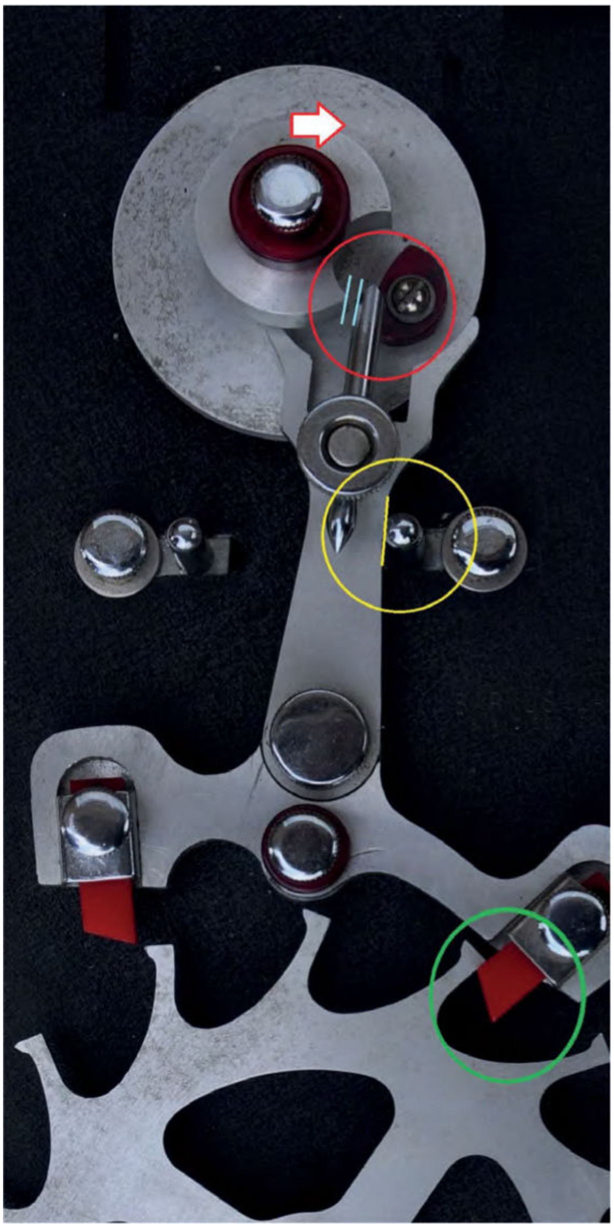


Fig. 144: The balance rotates in a clockwise direction and nears the notch and horns of the pallet.

At the instant of *unlocking*, a tooth is released. This gives an impulse on the exit pallet stone as the tooth pushes on the surface of the impulse plane of the exit pallet stone. Now, instead of the balance driving the pallet lever, the pallet lever is driving the balance wheel, giving it a propelling force to maintain the balance wheel's motion.

After the escape wheel tooth slides off the exit pallet stone, it travels a short distance *(drop)* until another tooth *locks* on the opposite pallet stone (entry stone). The escape wheel *draws* the entry pallet stone in towards its centre, causing the pallet lever to then strike the banking pin *(run to banking)*.

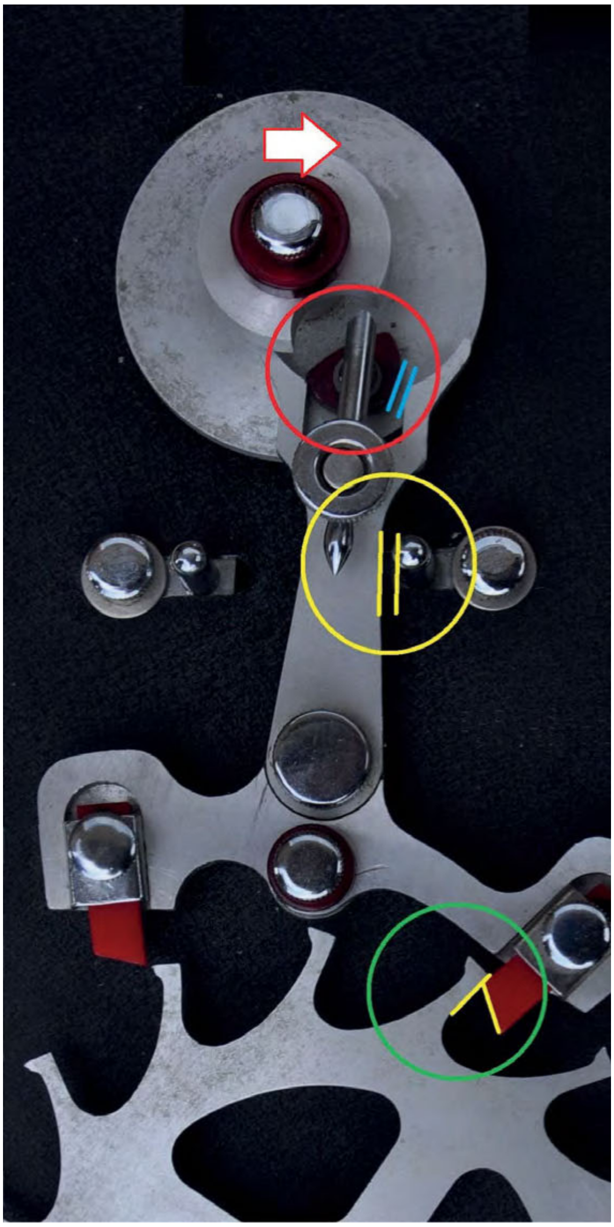


Fig. 145: The impulse pin enters the notch and moves the pallet lever. The escape wheel recoils slightly as the pallet moves.

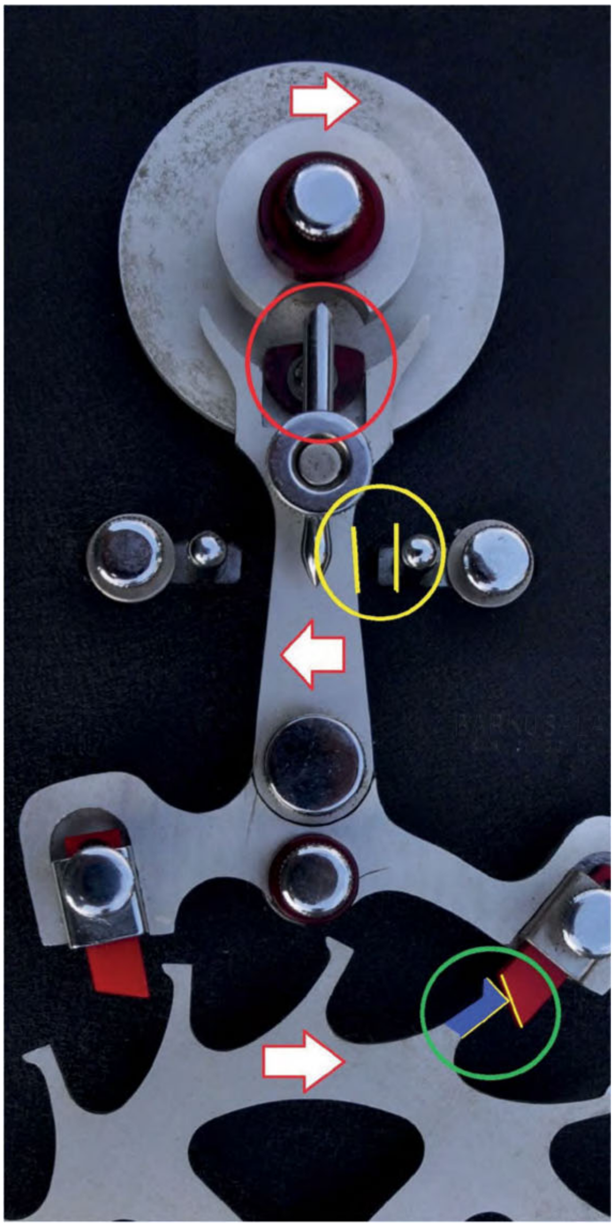


Fig. 146: The escapement is unlocked. Impulse is given to the exit pallet. The balance is now being given an impulse (push).

The impulse pin leaves the pallet notch and continues its free swing (supplementary arc) to the left. The inertia of the balance wheel is again soon overcome by the tension of the balance spring. A reverse in direction soon takes place and the balance wheel swings back in the opposite direction (clockwise). The whole cycle then repeats.

Let's look more closely at the shape of the impulse planes of the escape wheel and the pallet impulse planes.

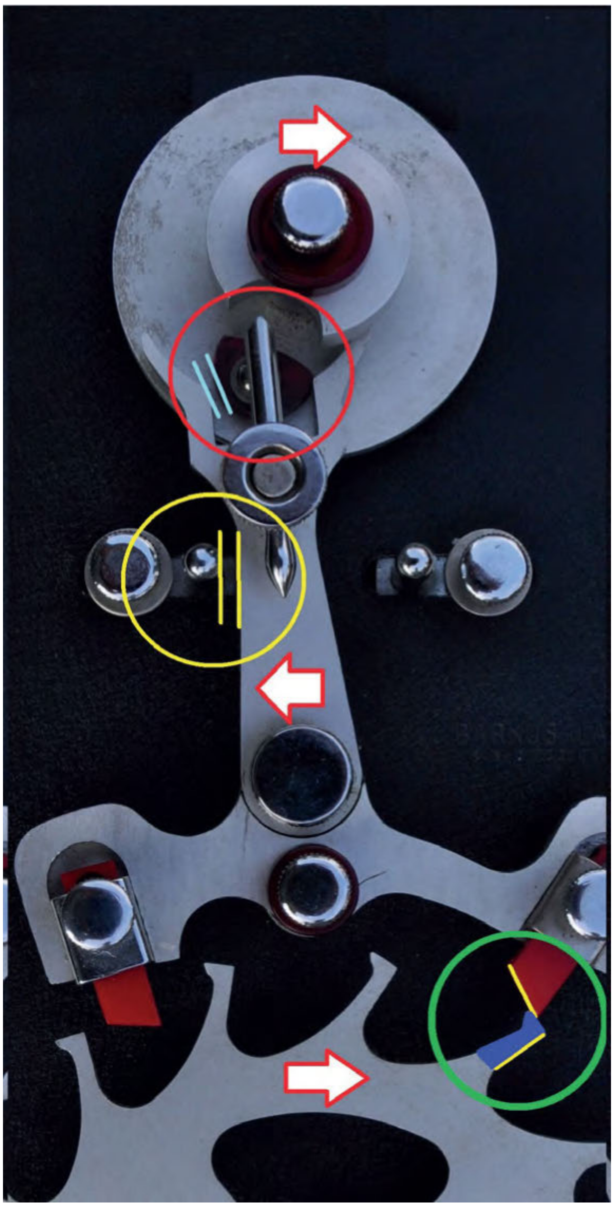


Fig. 147: Impulse from the escape wheel nears its end.

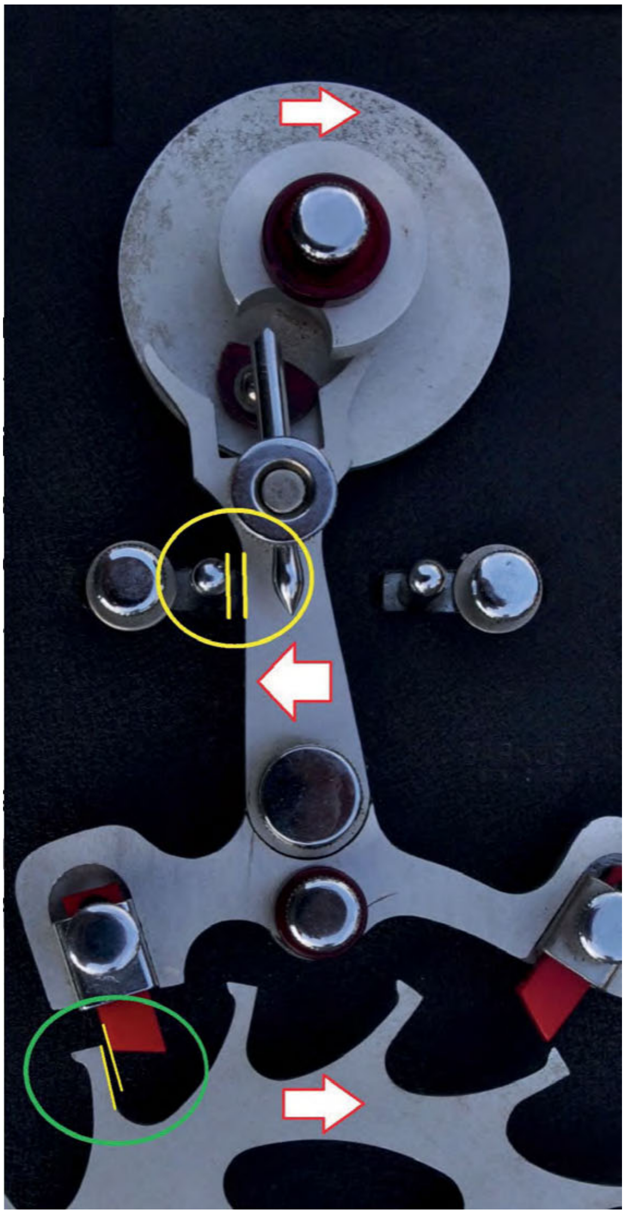


Fig. 148: The escape wheel tooth drops off the exit pallet. A tooth is about to lock on to the entry pallet.

The lever escapement is far from perfect, as there is a small amount of sliding friction taking place during impulse. To reduce this friction to almost nothing during impulse, the pallet stones and escape wheel teeth have been angled, so only a corner of either surface makes contact with the other (as shown in the pictures).

Due to the fact that sliding friction is present, it is necessary to apply a small amount of oil between the impulse plane's face and the locking plane of the escape wheel to reduce this friction to almost zero. However, this also impedes the escapement, as it relies on this lubrication. As most watch oils have a lifespan of no longer than five to eight years, this means that a lever escapement watch will require regular servicing to keep its time-keeping within normal parameters of plus/minus six seconds per day.

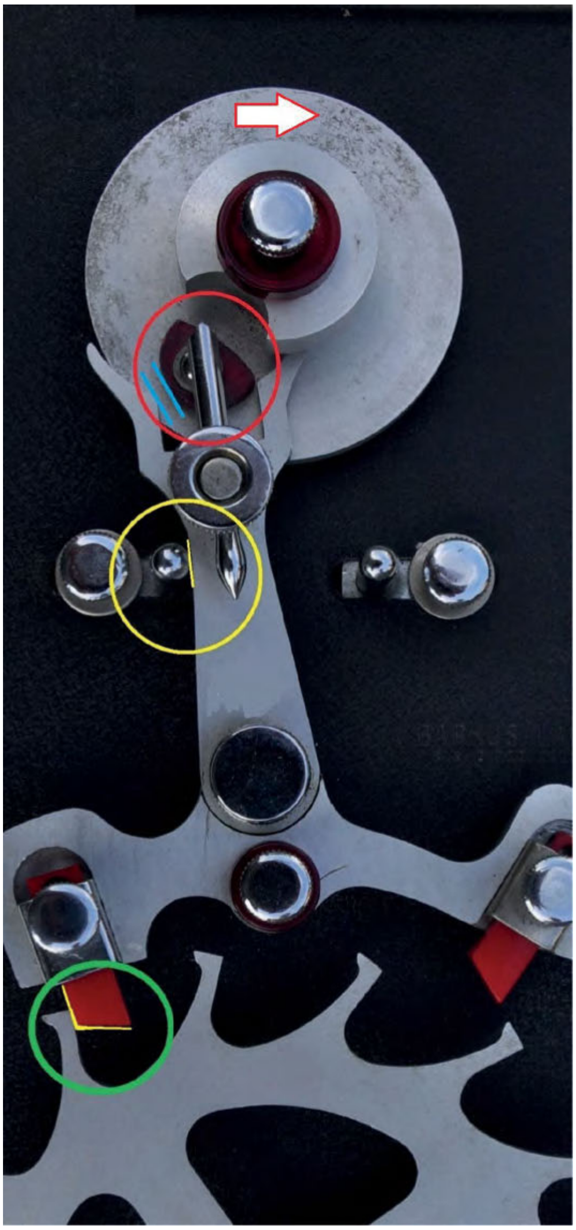


Fig. 149: A tooth locks on to the entry pallet. The impulse pin is about to exit the pallet notch.

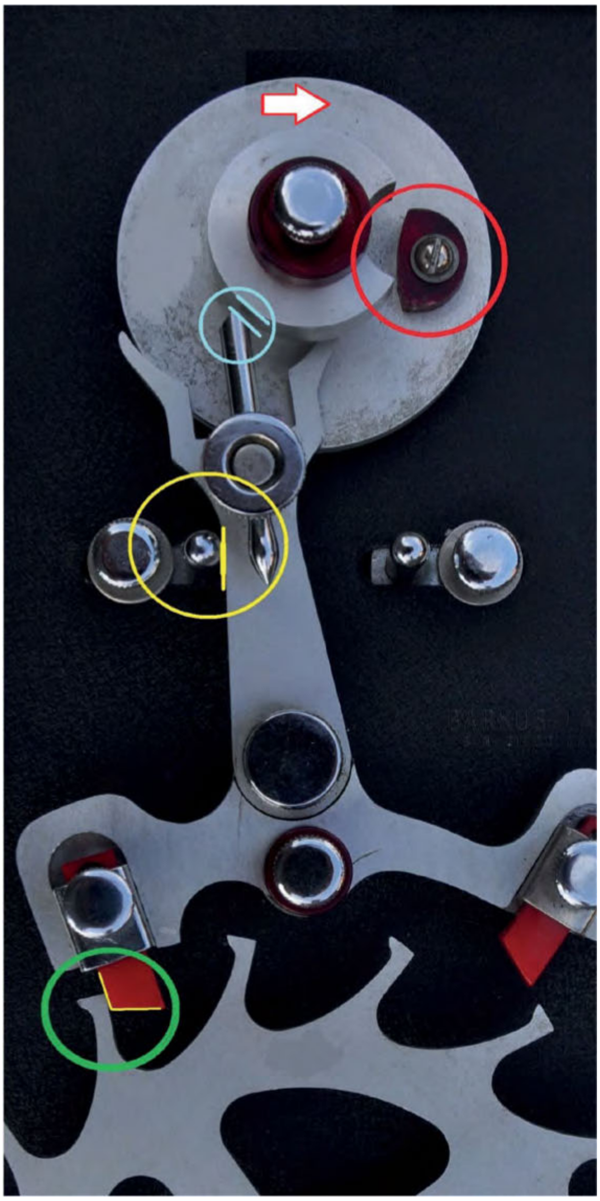


Fig. 150: The pallet is drawn into the escape wheel tooth. The lever strikes the banking pin. The balance swings clockwise. The action repeats.

SAFETY ACTION

A few little devices have been added to help with the human element of a watch. Just as aeroplanes have their safety equipment, so do watches, and these help keep the watch functioning during its daily life. Again, just like an aeroplane, a watch will experience turbulence and the occasional bumpy landing. These gizmos help prevent premature unlocking of the escapement or over-banking (complete locking or jamming of the escapement).

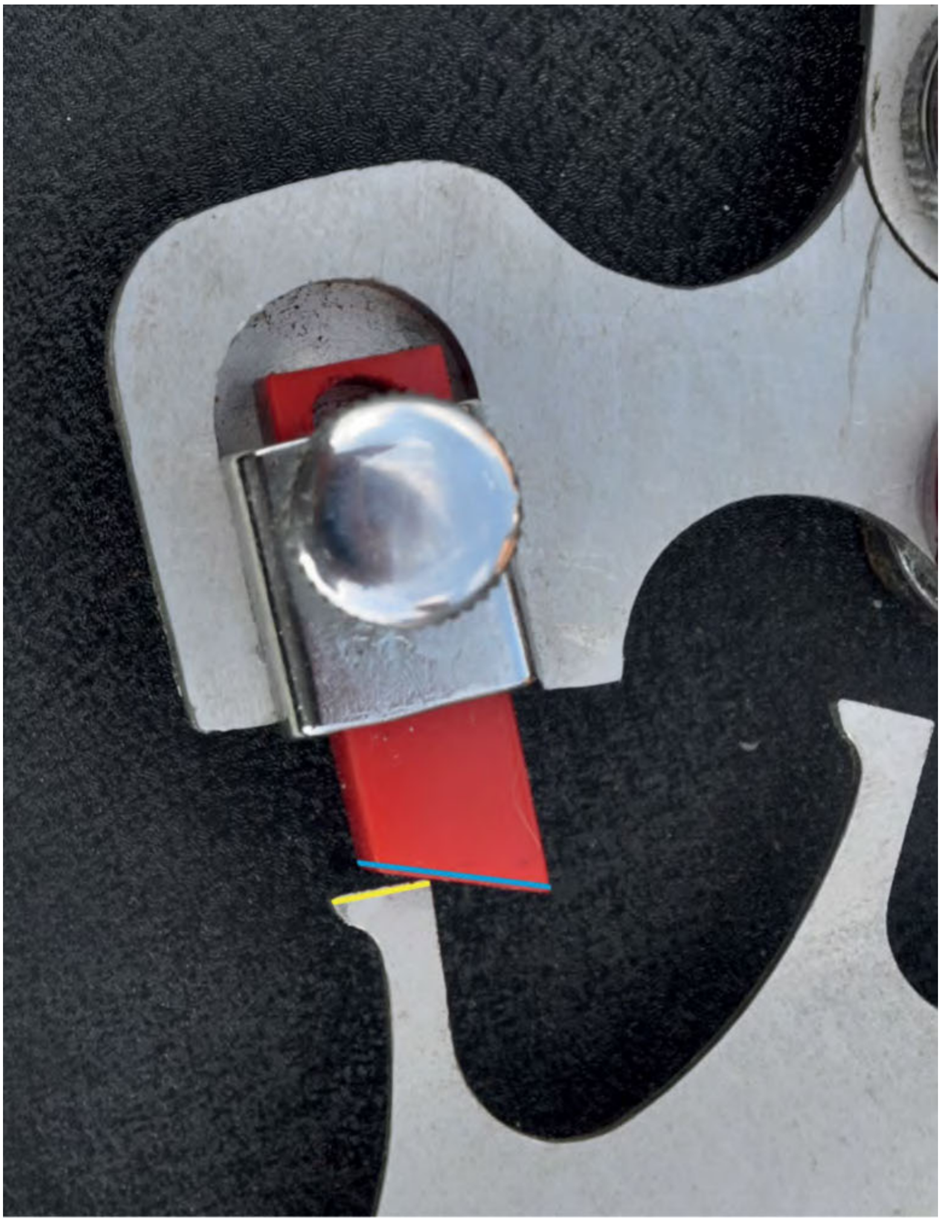


Fig. 151: The escape wheel tooth's entry corner is giving an impulse to the impulse plane of the entry pallet stone.

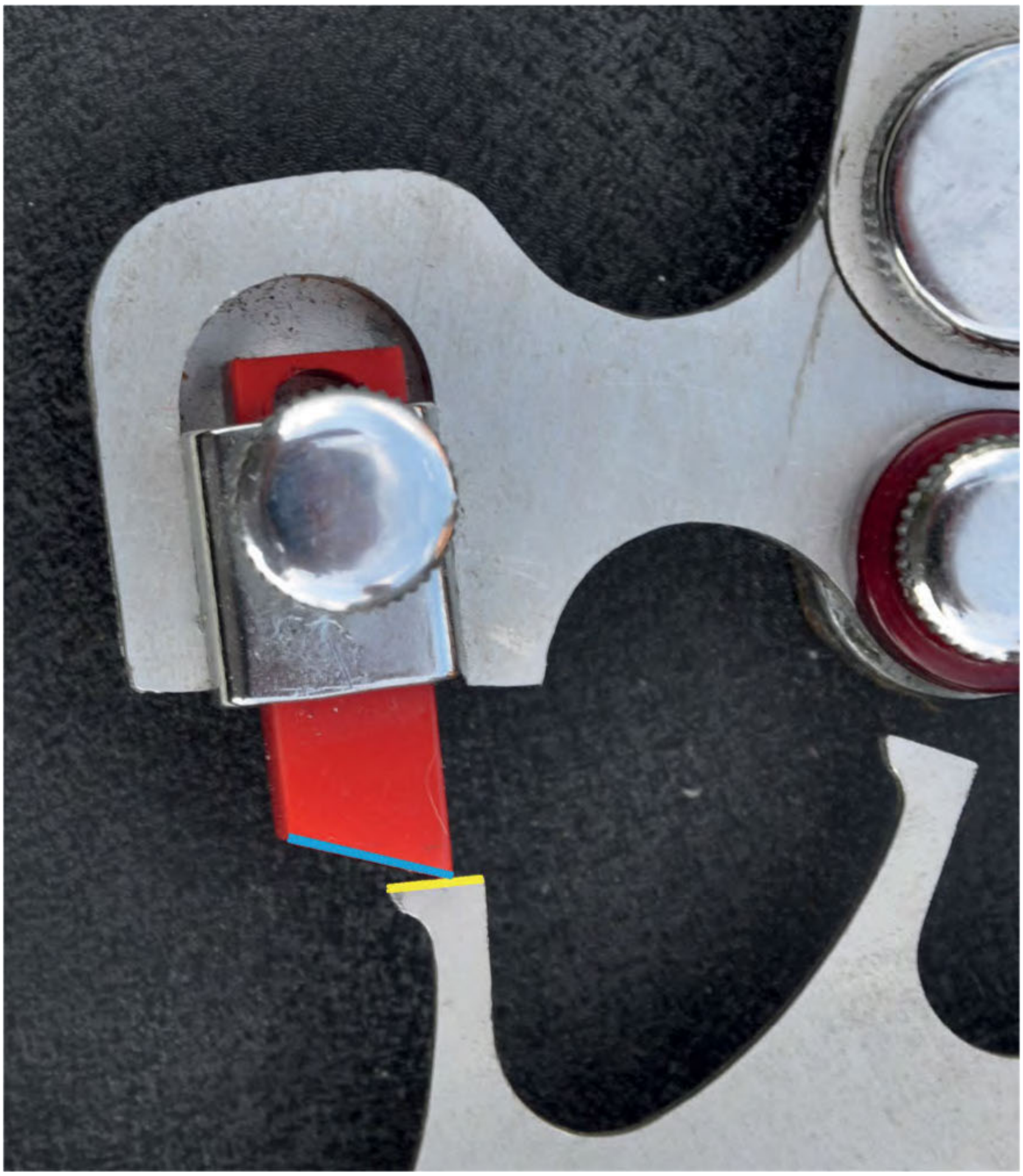


Fig. 152: Impulse is now being given from the impulse plane of the escape wheel to the discharge corner of the entry pallet.

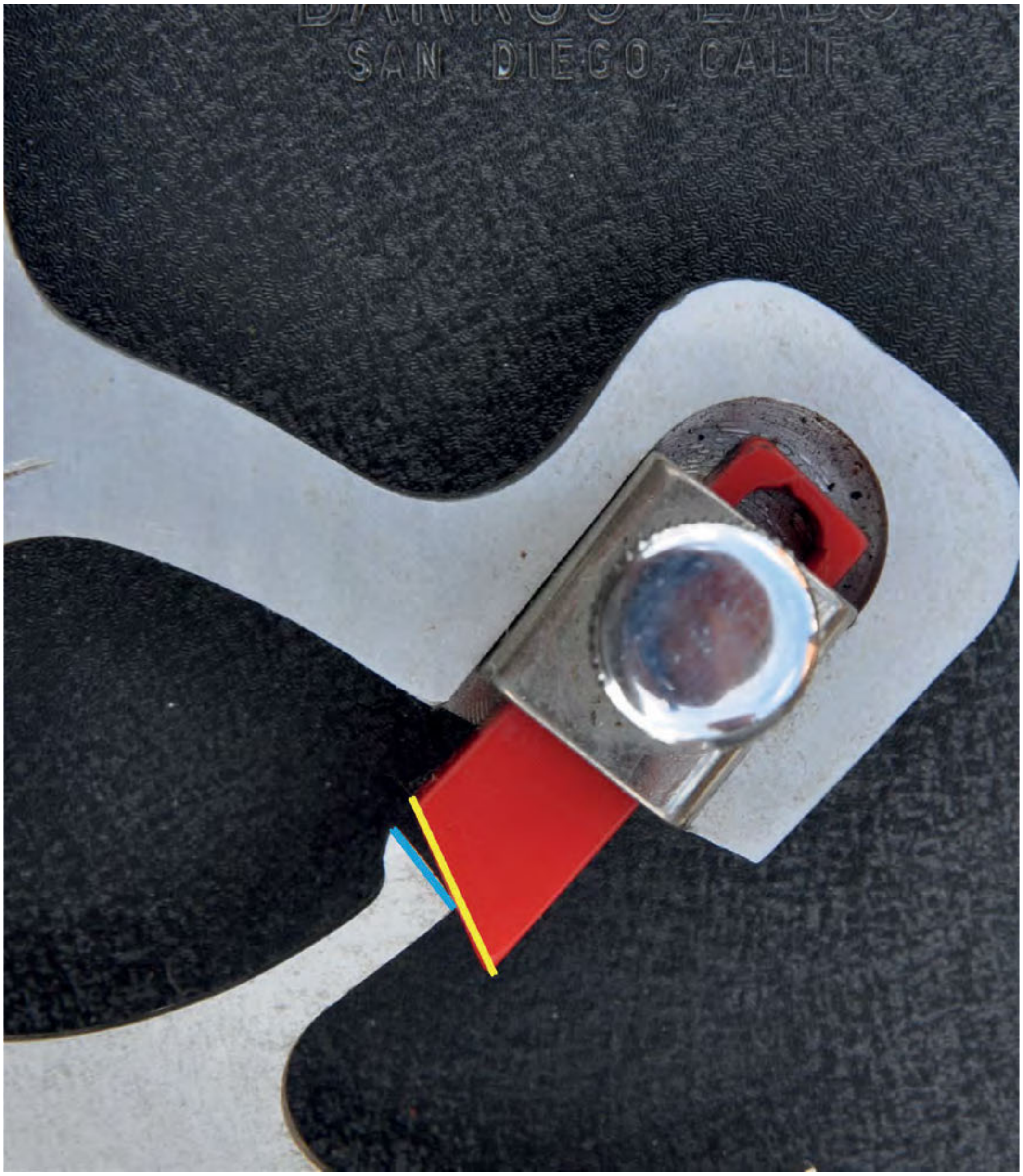


Fig. 153: The escape wheel tooth's exit corner is given an impulse to the impulse plane of the entry pallet stone.

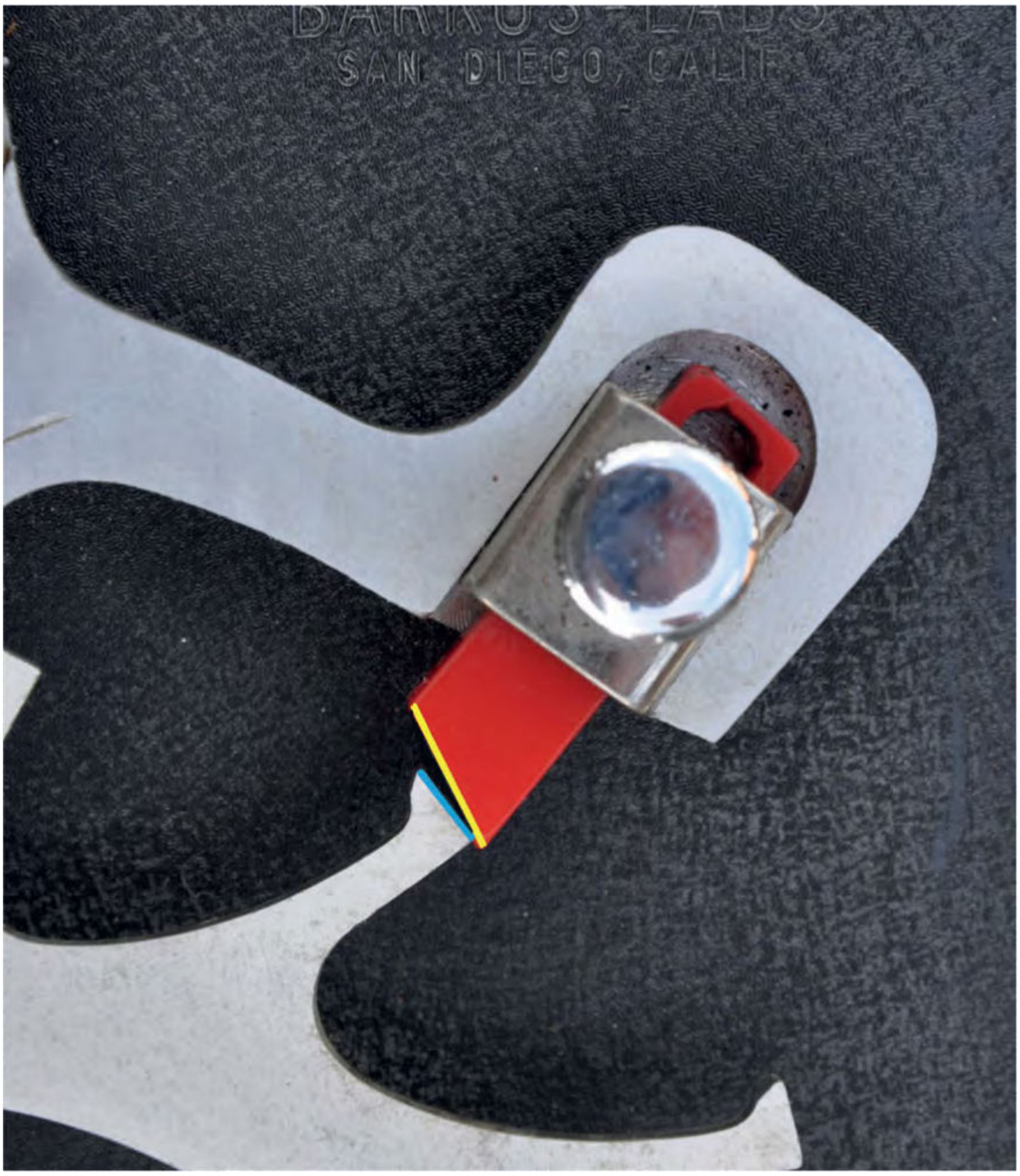


Fig. 154: Impulse is now being given from the impulse plane of the escape wheel to the discharge corner of the exit pallet.

The parts of the escapement involved in the safety action are the guard pin, the safety roller and the action of draw (draw happens just after locking of the escapement).

The Safety Roller, Banking Pin and Guard Pin

There are two types of roller found in lever watches. The first is the single roller, primarily found in early English and American watches. It is a flat steel disc with a small semi-circular section cut out of it (like PacMan’s mouth).Just behind this cut-out is normally a ruby or steel impulse pin.

The second type is the double roller. It has a circular disc at the top with the impulse pin on its outer edge. It also has a thin tube underneath, and attached to the end of the tube is a smaller disc with a small semi-circular cut-out. This style has now become the norm.

Both types of roller work in a similar fashion. The double roller has become the norm because it lends itself to thinner watches, therefore is perfect for wristwatches as the pallets move through a smaller arc. This means that the balance is in less contact with the escapement due to its size, thus improving the time-keeping of the watch.

How the Double Roller Works

When the impulse pin is out of contact with the fork, the escapement is vulnerable to turbulence. Hypothetically, if a watch didn’t have a guard pin, the lever could very easily flick over to the other banking pin with a small amount of vibration.

In such a situation, the impulse pin would not enter the notch on its return swing, but instead would hit the back of the horns of the lever. The energy in the balance spring would keep the balance held captive in this position, causing the watch to come to a sudden halt. This is known as being *overbanked*.

The crescent on the roller is there so that the guard pin can cross from one side to the other.

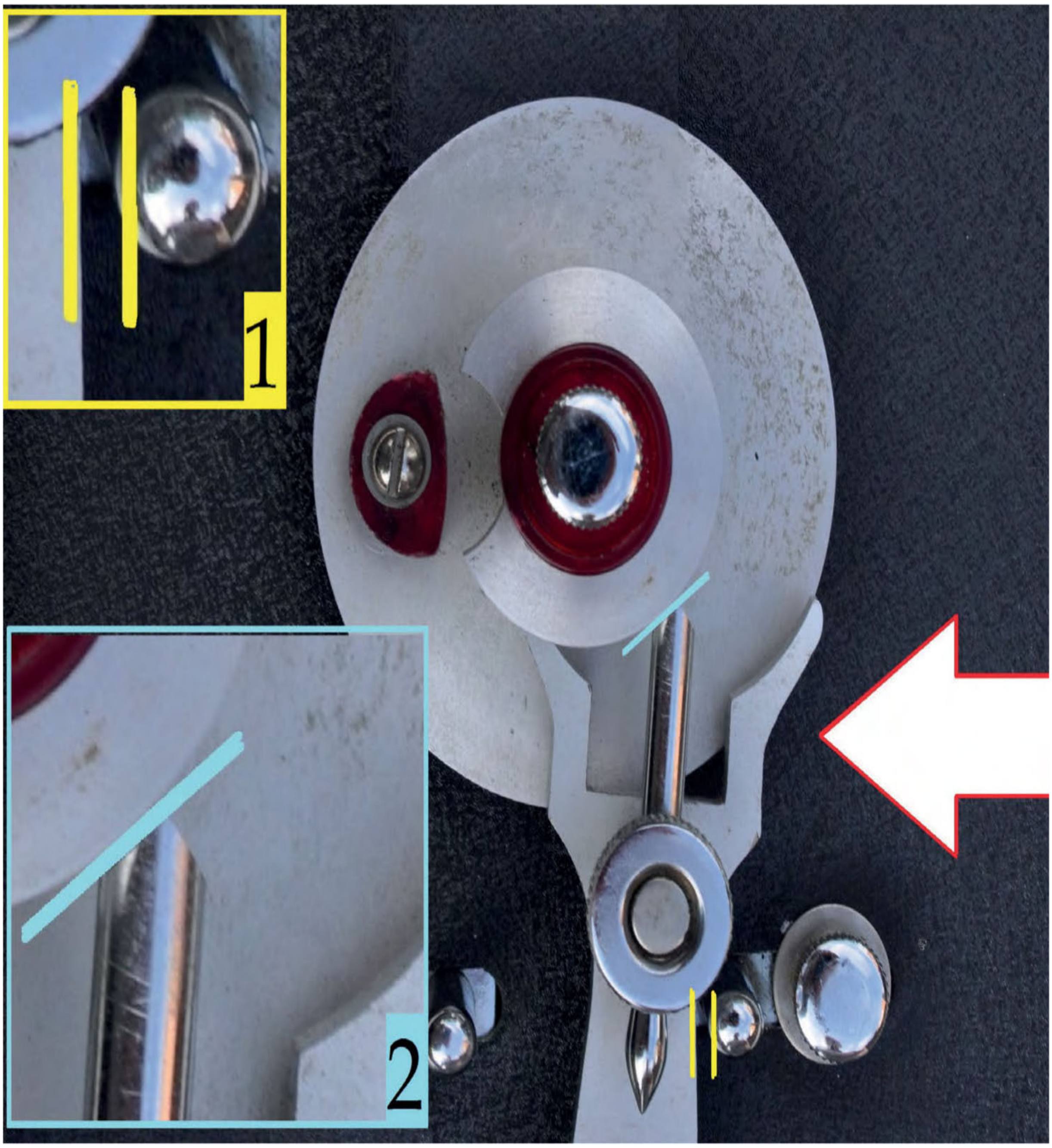


Fig. 155: The guard pin strikes the roller as the watch receives an impact from the righthand side. Image 1: Showing the pallet arm has moved away from the banking pin. Image 2: Shows the guard pin (dart) striking the roller.

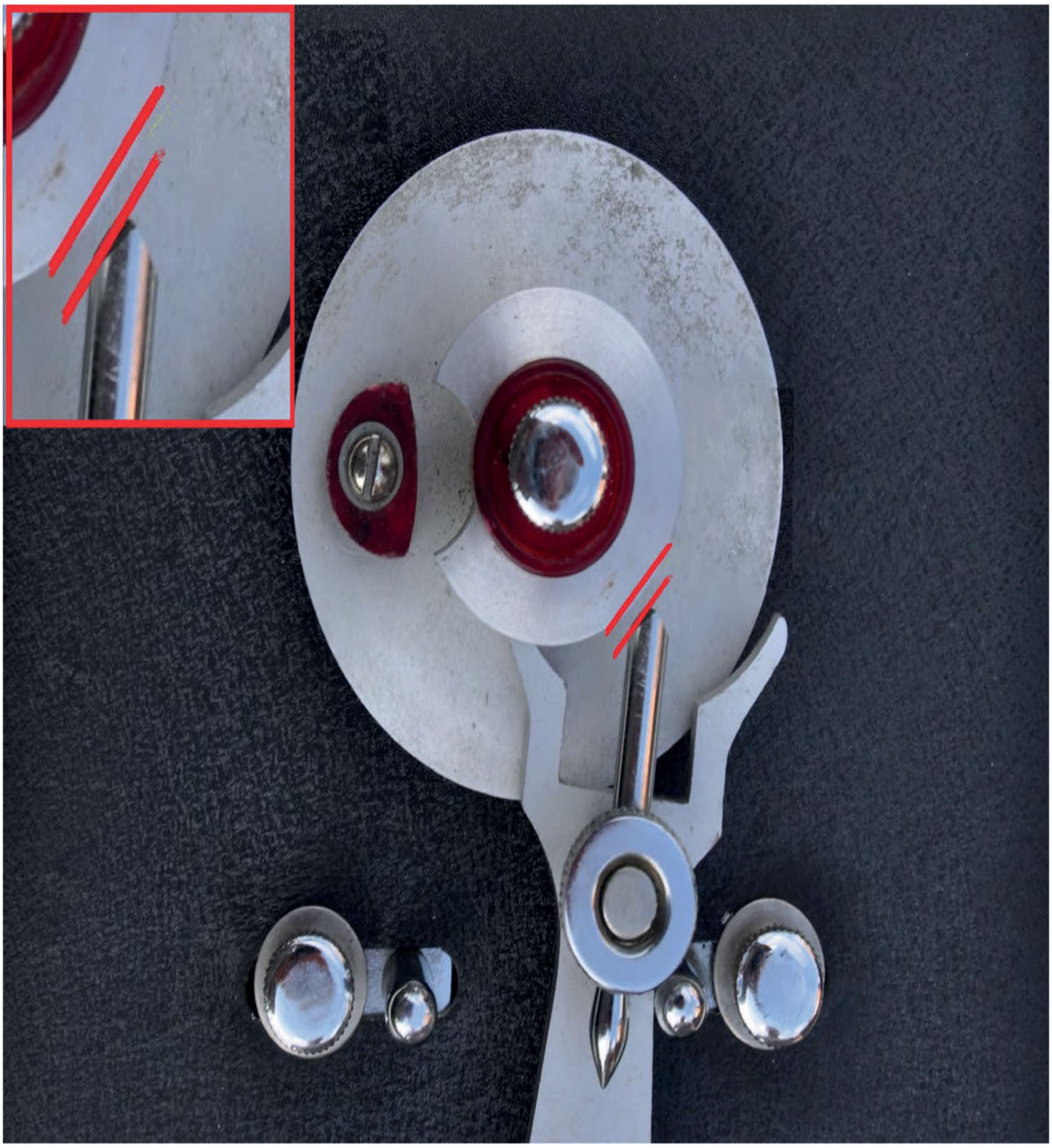


Fig. 156: Clearance of the guard pin in relation to the safety roller on the right-hand side.

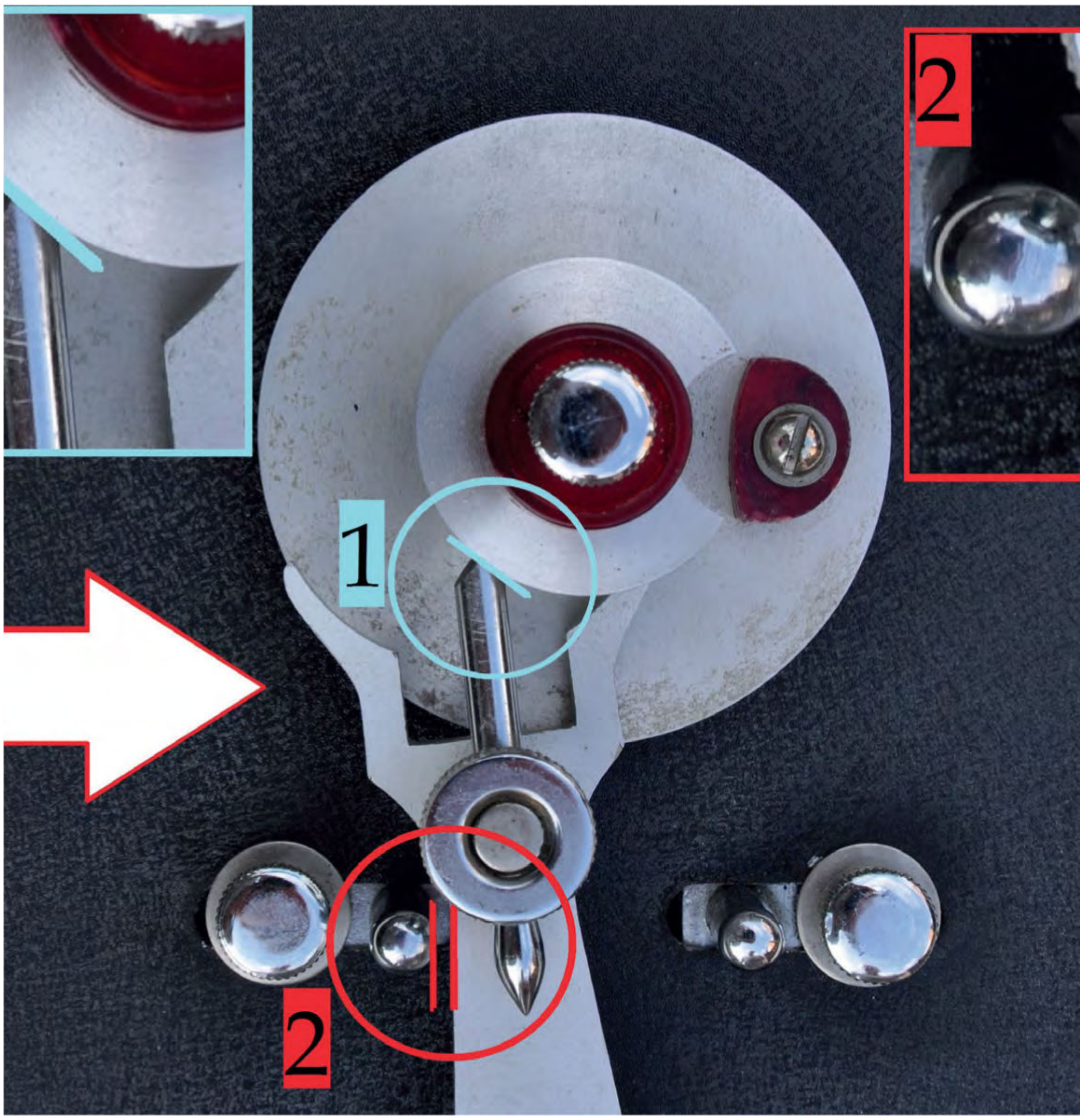


Fig. 157: The guard pin strikes the roller as the watch receives an impact from the left-hand side. Image 1: Showing the guard pin striking the roller. Image 2: Showing the pallet arm has moved away from the banking pins.

THE REASON FOR DRAW

Draw was mentioned in the action of the escapement, and the fact that the pallet stones were angled. It was discovered that, in early lever watches, if the watch was subjected to a jolt or turbulence, the lever could move away from its banking pin, causing the guard pin to hit the roller. This would then cause it to drag along the surface of the roller until the next impulse was given. The steady amplitude of the balance would be affected, causing poor timekeeping. By adding draw, the pallet lever is held tight against the banking pin.

A particular disadvantage of adding draw is that you have introduced a small amount of recoil during unlocking of the escapement. This means the balance wheel has to exert more energy during the moment of unlocking as it recoils from the escape wheel. The advantage of draw is that if the lever received a shock and did manage to move and hit the roller, the lever would be instantaneously drawn back to its banking pin. This is a very small compromise in order to improve the stable time-keeping of the watch.

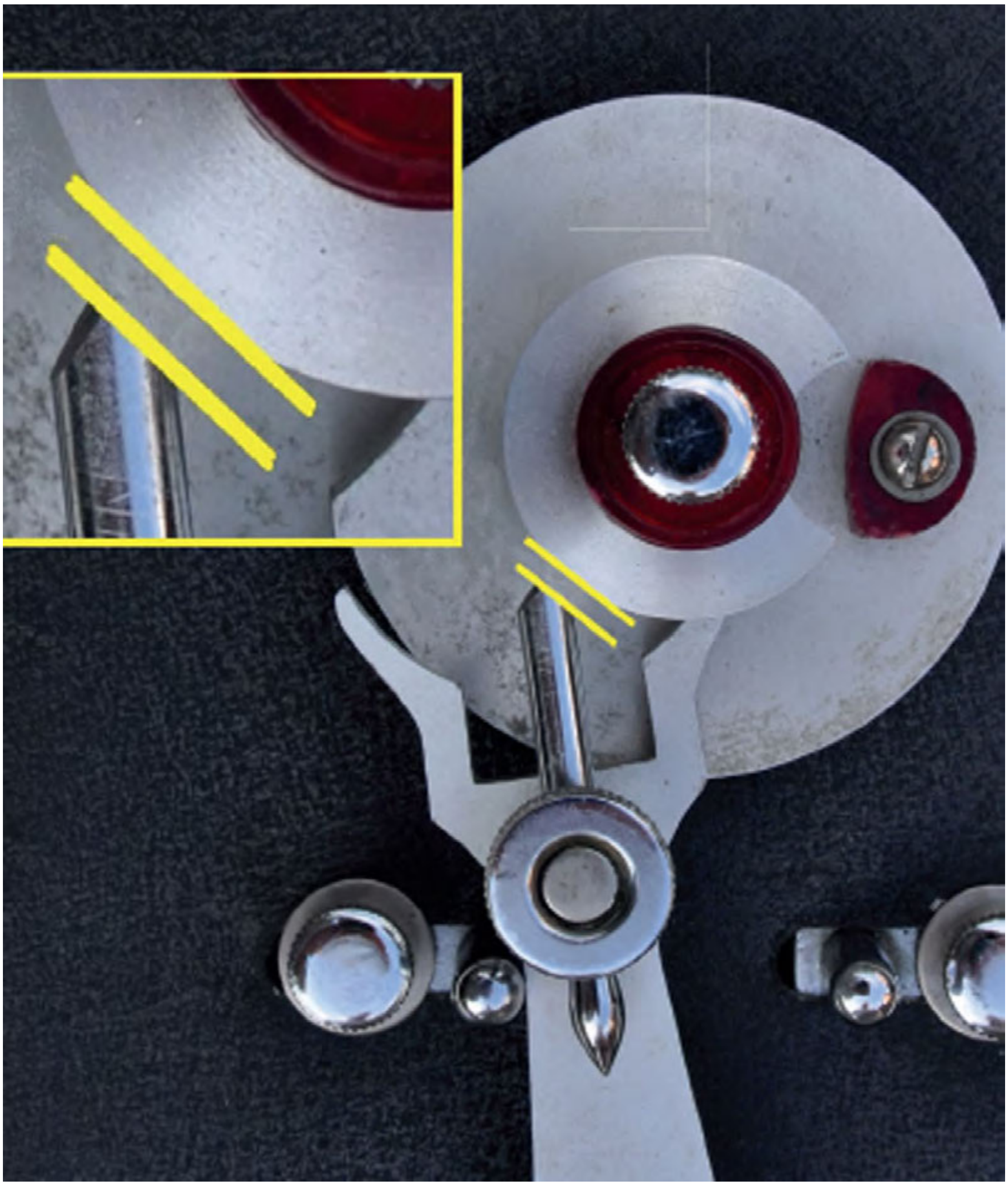


Fig. 158: Clearance of the guard pin in relation to the safety roller on the left-hand side.

You can just about see the action of the escapement and observe the draw of the pallets into the escape wheel. To do this, take a small piece of paper about 6mm long and 2mm wide. Fold this lightly in half so that it forms a V-shape. Lightly insert it under the pallet lever just under the guard pin, so it forms a brake.

With the tips of your tweezers, lightly and very slowly move the pallet lever left, then to the right. You should be able to observe the action of the escapement described earlier in slow motion.

23 THE BALANCE WHEEL

As we have discovered so far, the balance spring is a long, coiled strip of spring metal which is attached to the balance staff via the spring's collet. The other end is fixed to the balance cock via the stud. When the balance is given a push (impulse), momentum is given to the balance wheel. If we didn't have a balance spring, then the balance wheel would just spin. The power from the balance is stored in its coils until this power becomes greater than the momentum of the balance wheel, causing the balance to reverse and this makes the balance oscillate. This oscillation allows the balance to return towards its zero position to receive the next impulse in the opposite direction from the escapement.

The oscillating effect alone isn't enough to make a watch keep time. All watches have some method of regulation or means to control the speed at which the hands turn. This is not just controlled by the gearing or the escapement: the final piece of the puzzle is the balance wheel and its spring.

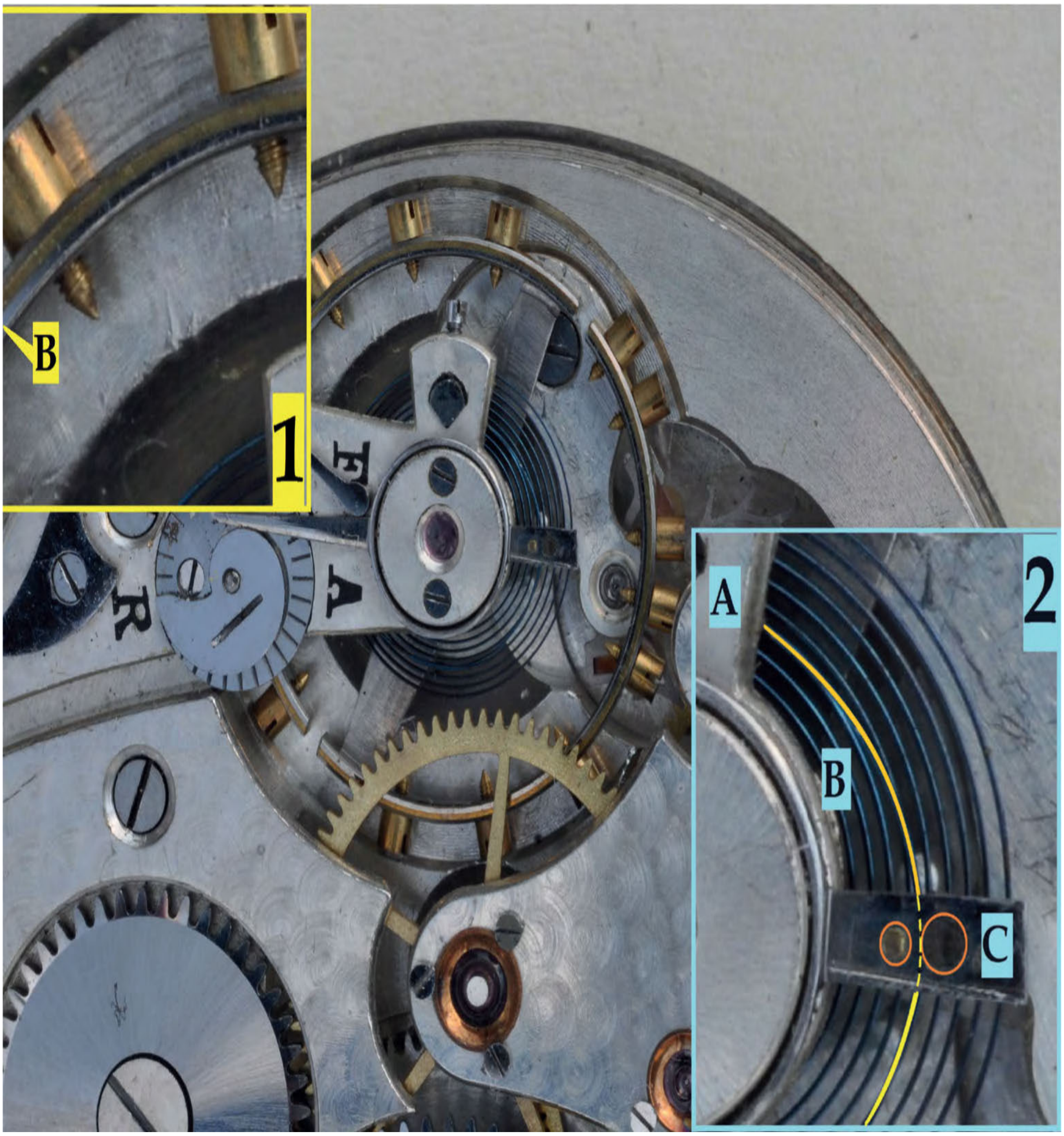
The balance wheel and its spring are the main control of the rate (time-keeping) at which the watch runs. Balance wheels come in many different styles and sizes.

The rate of older watches can be affected by temperature change. This is due to the materials the watches were made of. The balance wheel is made of a particular type of metal, and all metals expand and contract with temperature change, to varying degrees. This will affect the radius of gyration, as the balance wheel becomes smaller in colder temperatures, making it run fast, and larger in higher temperatures, making the watch run more slowly.

Temperature changes can also affect the elasticity of the balance spring. The use of a bi-metallic balance helps to minimize the variance this causes, as well as that of the expansion/contraction of the balance wheel. Temperature isn't much of an issue with modern watches, as the balance wheel and its spring are made from alloys (metal mixtures) that have a low expansion rate.

TYPES OF BALANCE WHEEL

The two most common types of balance in modern and antique watches are the bi-metallic balance, and the plain/annular balance.



Bi-metallic Balance

Fig. 159: Bi-metallic balances. Image 1: (A) Brass rim of the balance wheel. (B) Steel inner rim of the balance wheel. Image 2: (A) Stud (fixing point of the spring). (B) Cover coil spring. (C) index pins. A watch with an over-coiled balance spring is best left to more experienced watch repairers, as these are very easily damaged.

A bi-metallic balance is where the rim of the balance has been made of two strips of metal (one brass and one steel).This outer rim is also cut through either side of the balance's centre crossing, so that the balance now has two semi-circular arms. The theory behind the balance wheel is that brass has a bigger coefficient of expansion than that of steel, so as the two bands of metal are joined together, this causes a natural bending effect as the two metals expand and contract at different rates. In cold weather, this would cause the balance rim to bend outwards, cancelling out the natural shrinking effect of the balance wheel. The opposite occurs in hot weather, as the balance rim bends inwards, compensating for the expansion of the whole balance.

Plain Balance or Annular Balance

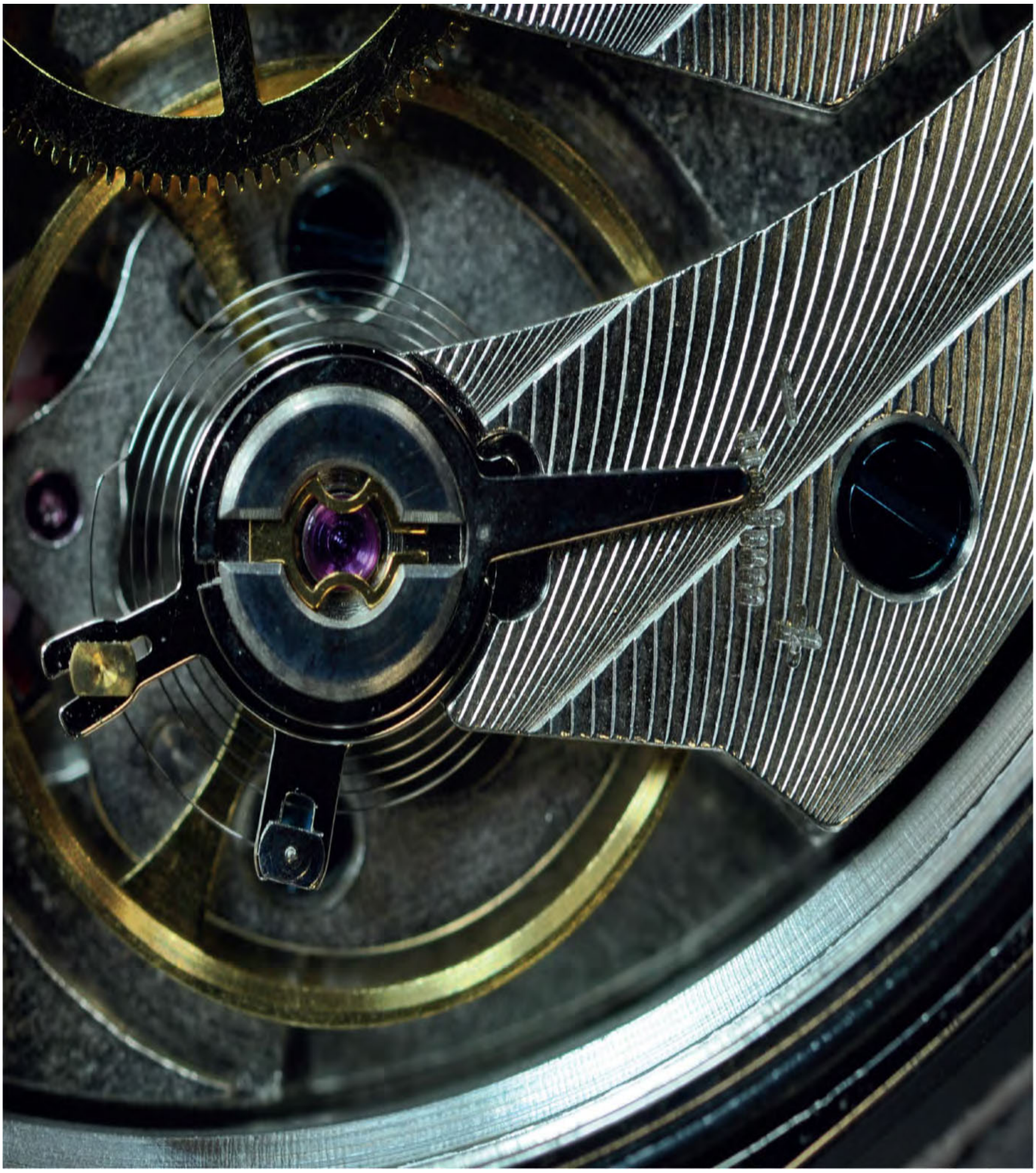
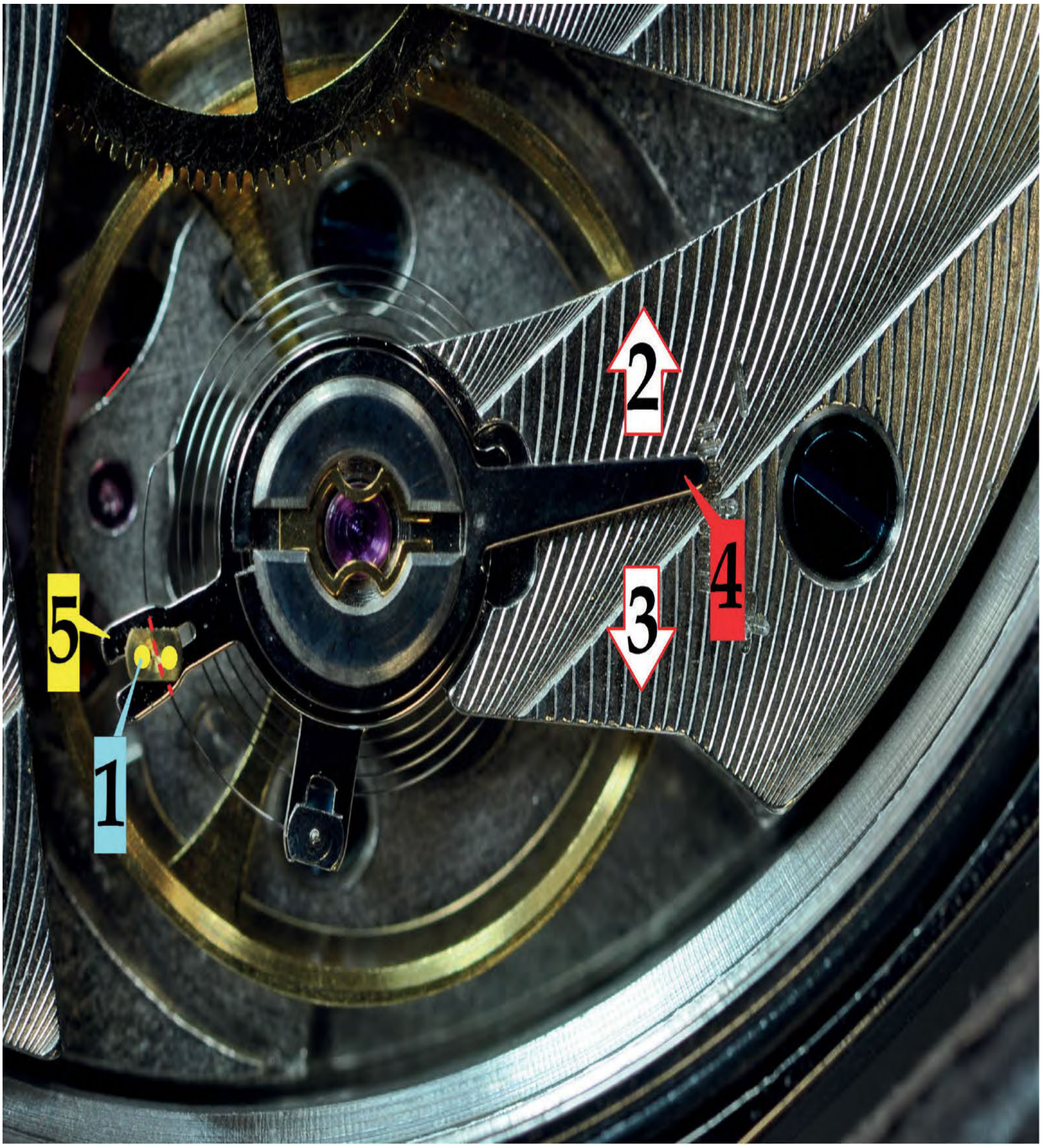


Fig. 160: Mass-produced plain balance with three crossings or arms.

This is the most common type of balance wheel found in watches. It has a smooth rim with two or three crossings, made from one type of material. This is why they are used in mass production. They are commonly made from a nickel or beryllium alloy and are paired with a balance spring made from Invar or Elinvar.



The Index

Fig. 161: A closer look at the index: (1) Index pins. (2) Moving the index in this direction retards the watch (runs more slowly). (3) Moving the index in this position advances the watch (it runs faster). (4) Tail of the index. (5) Index.

The most common method of regulation is the index. This is an adjuster which interacts with the outermost coil of the balance spring. If you look at the balance in its current position, part of the index will be visible and you will see either index pins or a boot and index pin.

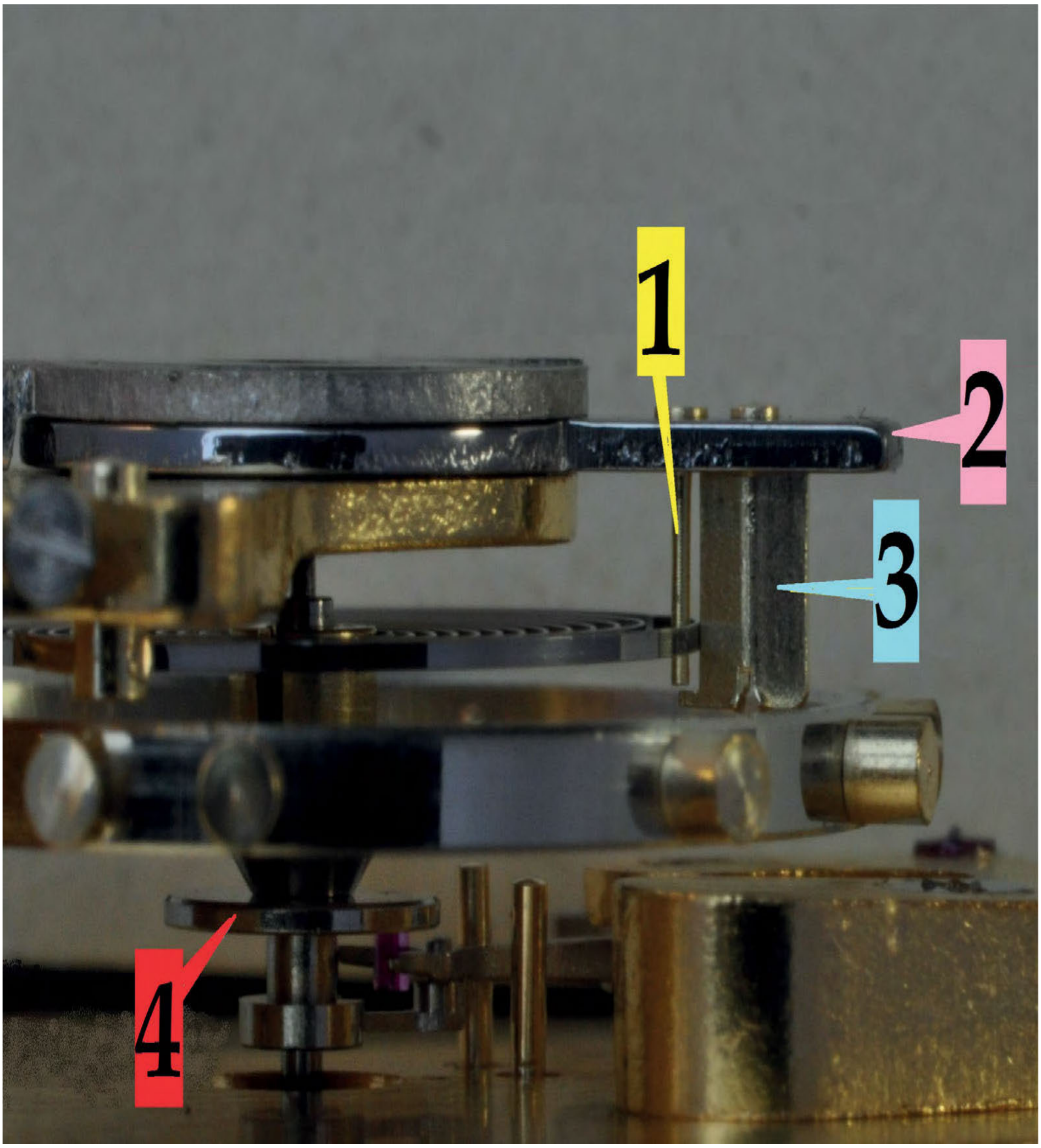


Fig. 162: Side view of an index: (1) Index pin. (2) Index. (3) Boot, or sometimes a second index pin. (4) Side view of the roller.

The index pins: These are two little brass pins through which the outermost coil of the balance spring passes.

Boot and index pin: A small brass block shaped like an old-fashioned boot (and called the boot), and one brass pin resting next to the toe of the boot. The outermost coil of the balance spring passes in between the boot and pin.

Whether the index is fitted with two pins or a boot and pin, they both work in the same fashion in that if the index is moved, it will change the usable length of the spring. This will have the effect of slowing down or speeding up the watch, affecting the rate, or regulation. When you come to refit the balance wheel you will notice that the index is normally engraved on each side of its tail end, with an ‘A’ for ‘advance’ (fast) and an ‘R’ for ‘retard’ (or slow). The longer the balance spring, the more slowly the balance will oscillate; the shorter the balance spring, the faster it will oscillate. The index will normally adjust the rate of the watch within a minute or two plus or minus.

If a watch is running out of this tolerance, there must be an underlying problem. This is normally because the watch needs cleaning, or the balance spring may be out of adjustment. Any adjustment of the index is made in very tiny increments.

Free Sprung Balances (Watch with no Index)

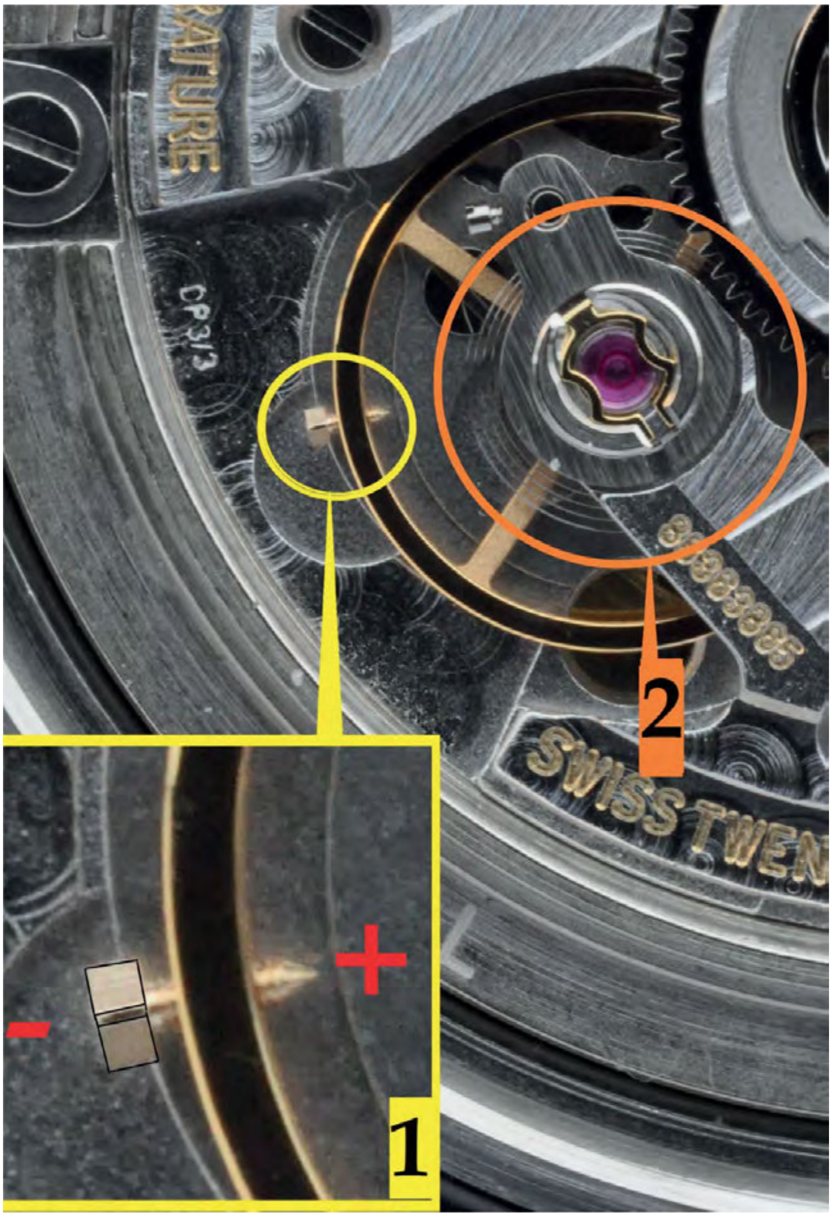


Fig. 163: Image 2: A free-sprung balance (with no index). Image 1: Timing screws for regulation.

Higher quality watches do not install an index as this interferes with the natural frequency of the balance wheel/spring. These balances can be fine-tuned to change speed for regulation via timing screws. These screws work by moving the balance's mass outwards, causing it to oscillate more slowly. If the screws are used to move the mass into the centre, the balance will increase in speed (just like a figure skater spinning around with their arms spread out wide; if they move their arms closer to their body, their spinning speeds up). Moving the mass of the balance closer to, or further away from, the balance’s centre is known as ‘changing the radius of gyration’.

This type of regulation is really only used on very high quality chronometer watches, such as those made by Rolex, Panerai or Omega. These watches require special keys/tools to regulate the balance wheel by adjusting the timing screws, so it is best that they are returned to specialized service centres, where they have the correct tooling. Without these tools, the geometry of the balance can be easily affected, causing positional errors in timing.

24. REFITTING THE BALANCE AND ITS COCK

To refit the balance wheel, you must first be aware of the position of the pallets (that is, whether the exit or entry pallet is currently locked). This is because you must fit the balance wheel so that the impulse pin is the right side of the pallet horns. Incorrect fitting of the balance wheel will result in an over-banked escapement (an escapement that is locked). Most beginners tend to play what I call ‘balance roulette’ when they fit the balance, so here’s a way to fit the balance wheel without the trial and error.

First, look at the pallet to see which pallet stone is locked, and then follow the instructions below.

EXIT PALLET STONE LOCKED

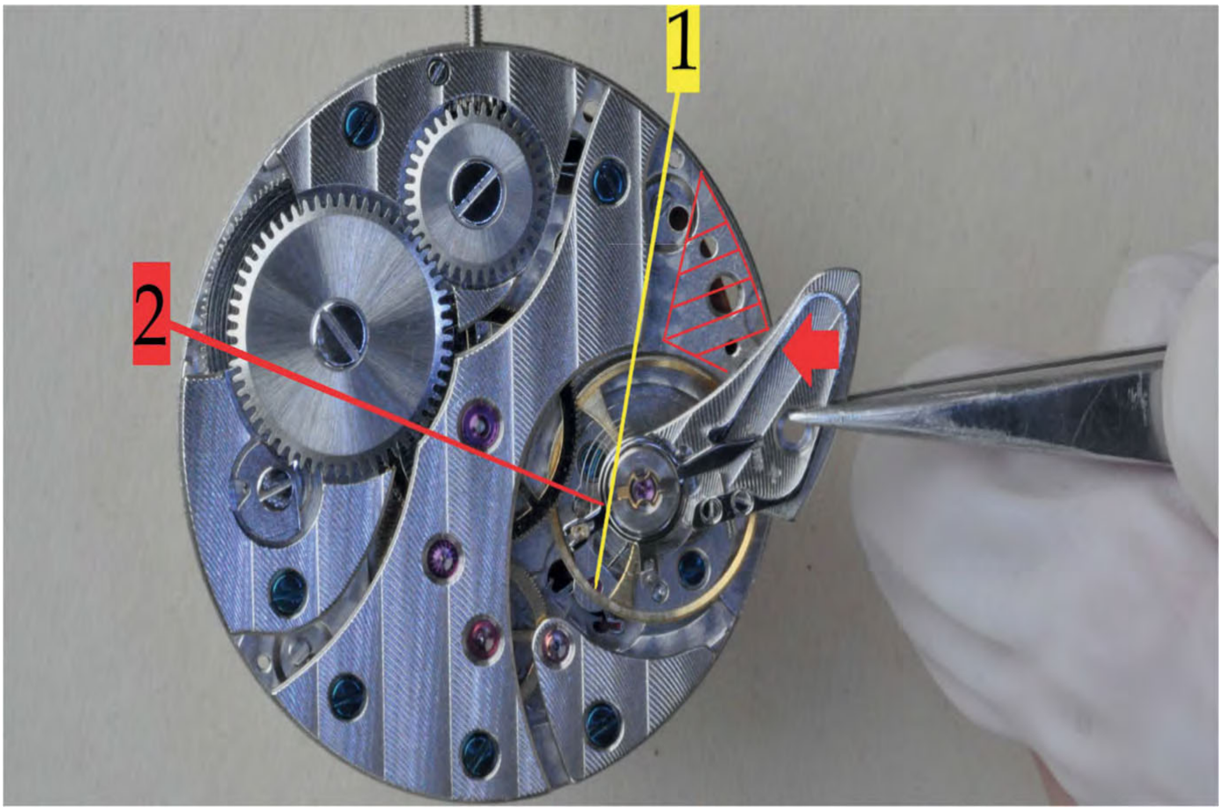


Fig. 164: Refitting the balance wheel: (1) Direction of the pallet (pointing towards the centre wheel). (2) Direction of the impulse pin.

When the exit pallet stone is locked, the pallet horns will be pointing towards the centre wheel.

If you stored your balance correctly, it should be upside down in your storage container, and to refit it you will first have to turn it over so it is the right way round. To do this, you will only need to use the tips of your tweezers on the underside of the balance cock. Do not try and flip the balance assembly by trying to use the balance wheel, as you will end up with the balance spring looking like a twisted slinky.

Once the balance is the right way round, you must lift it up as you did when you removed it, by holding it with your tweezers at the point where the thinner part of the balance cock joins the larger block (shown in [the picture] Fig. 164). Once the balance wheel is held by your tweezers you must be aware of the position of the impulse pin on the balance wheel, and to ascertain roughly where it is.

Tip: You can look at the end of the index (or regulator), as normally the impulse pin is pointing in this direction.

As you lower the balance into the watch you must tuck the wheel under the centre wheel. Secondly, you must locate the bottom balance pivot in its jewel hole in the main plate. Once the bottom pivot is located you can now locate the balance cock into the plate.

Tip: Rather than trying to be a contortionist, twisting your wrist and arm to locate the balance cock, an easier way is to rotate the movement with your free hand, to mate the balance cock and the plate. Line up the balance cock’s steady pin in the base plate’s holes. Use the tips of your tweezers to straighten up the balance wheel. Carefully tap the balance cock to level it off.

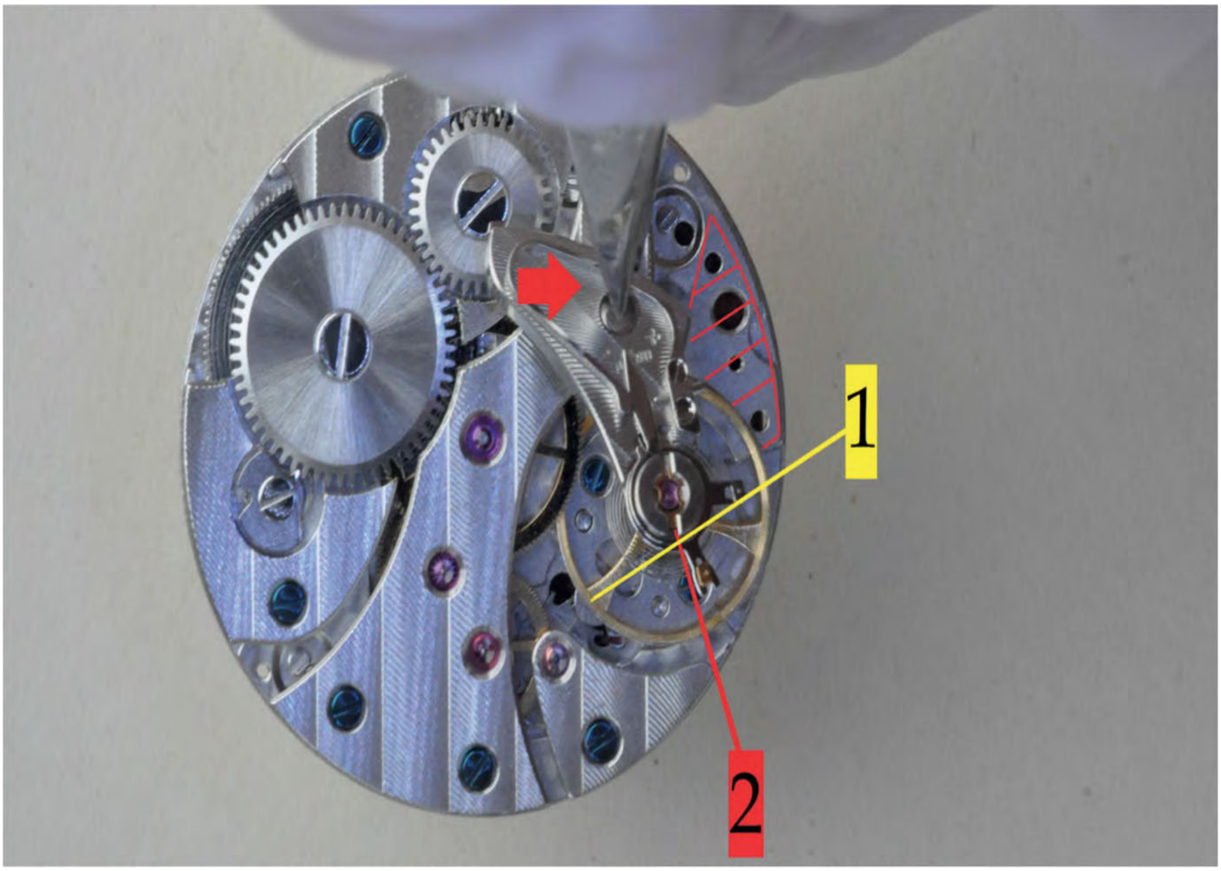
If the balance’s pivots are in their jewel holes, take your watchmaker’s bellows (or puffer) and give the balance wheel a puff of air from the side. This should start the balance wheel swinging (if it isn’t already).

Tip: When fitting a balance in a watch it is always best to do so when there is power in the gear train, so always remember to give the watch a few winds whenever you fit a balance wheel back into a watch. If the watch fails to start, make sure the balance wheel is sitting nice and level in the movement, and that the balance spring hasn’t got trapped in the teeth of the centre wheel. If it still fails to start, try removing it and have a second attempt at refitting it, as the pallets may have switched position and the balance wheel may now be overbanked. If you still fail to refit the balance wheel, remove it, lie it on its back, and then have a good look at the pivots on the balance's staff, to make sure that it still has two matching pivots.

Take care when refitting the balance wheel. If it stops swinging when you're tightening up the screw, quickly loosen it by one turn. Look carefully at the balance wheel, as its top pivot may have popped out of its top jewel hole. If it has, you may have to loosen the balance cock so you can lift it adequately, allowing you to relocate the pivot safely in its hole.

If this is not the case, the balance cock could be sitting at an angle. You will have to straighten it up and then proceed to tighten up the balance cock's screw.

ENTRY PALLET STONE LOCKED



When the entry pallet stone is locked, the pallet will be pointing away from the centre wheel.

Fig. 165: Refitting the balance wheel. (1) Direction of the pallet (pointing away from the centre wheel). 2. Direction of the impulse pin.

Hold the balance cock in the same manner as before, but this time you have to approach the movement with the balance wheel so that the fatter part of the balance cock is hovering over the movement in line with the ratchet wheel (shown in [the picture] Fig. 165).Tuck the balance wheel under the centre wheel and tease the balance wheel's bottom pivot into its jewel in the base plate. Rotate the movement so that the cock is in the correct position in the movement, taking care that the balance cock's steady pins line up with the holes in the base plates. Use the tips of your tweezers to straighten up the balance wheel, and carefully tap the balance cock to level it off.

If the balance's pivots are in their jewel holes, take your watchmaker's bellows (or puffer), give the balance wheel a puff of air from the side, and this should start the balance wheel swinging. If the watch is ticking away nicely, drop the balance cock's screw in its hole and proceed to tighten it up.

Tip: Do remember to check that the balance wheel is spinning freely during this process.

25. GEARING AND THE GEAR TRAIN

To understand gearing you first have to understand the very basics, which may be explained in four stages.

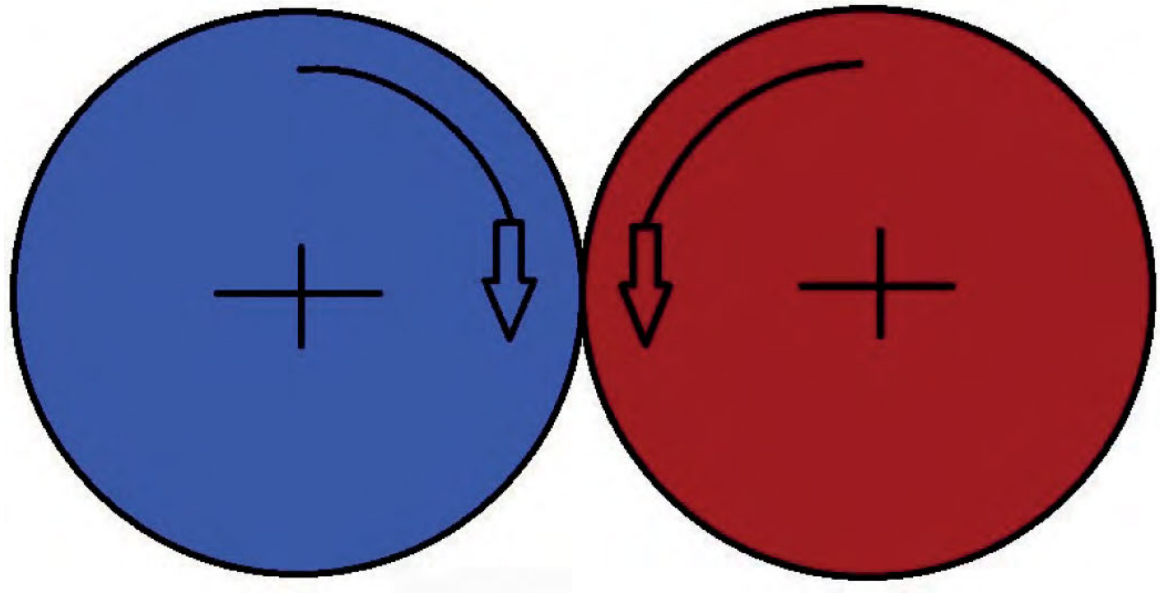


Diagram 13: Two rolling circles the same size.

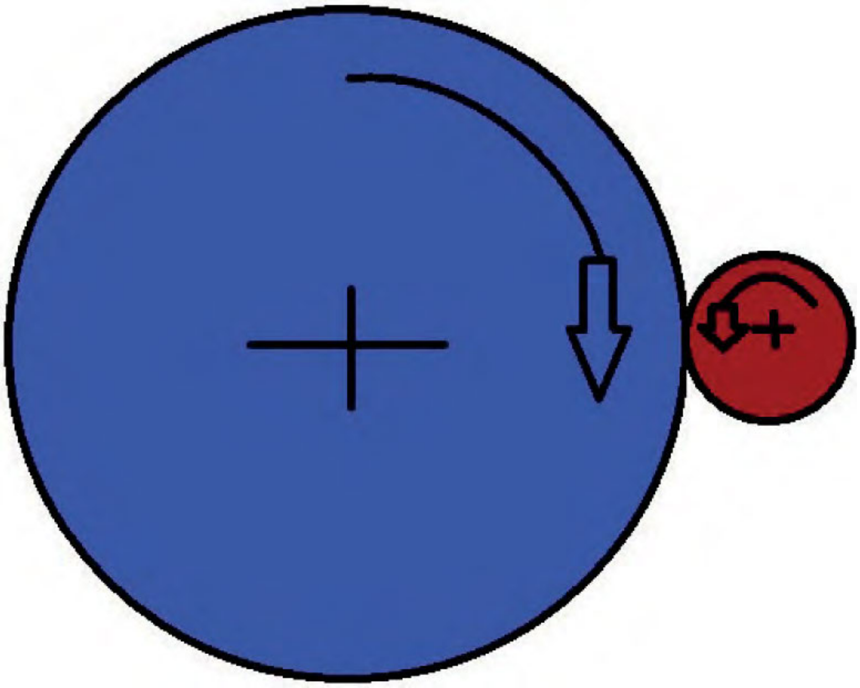


Diagram 14: Two rolling circles, where one is twice the size of the other.

Stage one: This is basic gearing, which most simply consists of two smooth rolling circles, both the same size, one pushing against the other to make its neighbour rotate at the same speed, but in the opposite direction, giving a ratio of 1:1.

Stage two: The second circle is made four times smaller in diameter than the first wheel. This will make the smaller wheel rotate four times more than that of the larger gear in the same time, giving us a ratio of 4:1.

Theoretical gearing is all right, but having to rely on the mutual friction of the two circles pressing on each other to prevent them from slipping would give an unreliable transference of energy. In gearing you need to have a smooth transmission of power flowing throughout the gear train, known as ‘uniform lead’.

Stage three: The next stage is adding teeth that look like square pegs. This is probably the worst type of gearing imaginable. You would eradicate the slipping, but the smooth motion we need for uniform lead would be diminished. This would be like having square wheels on your car: they would judder when rotated, caused by the teeth engaging and disengaging, and there would be friction due to the poor tooth shape.

Stage four: Teeth with rounded tops. Providing all the teeth have been rounded off the same, then the two gears would rotate reasonably smoothly. Early clockmakers did this and of course their clocks worked. In the early years of clock- and watchmaking very little was known about the theory behind either gearing or tooth forms; like most inventions they found out by trial and error and by rule of thumb. This is not the case with modern gearing, which will be discussed later in this chapter.

TYPES OF GEAR

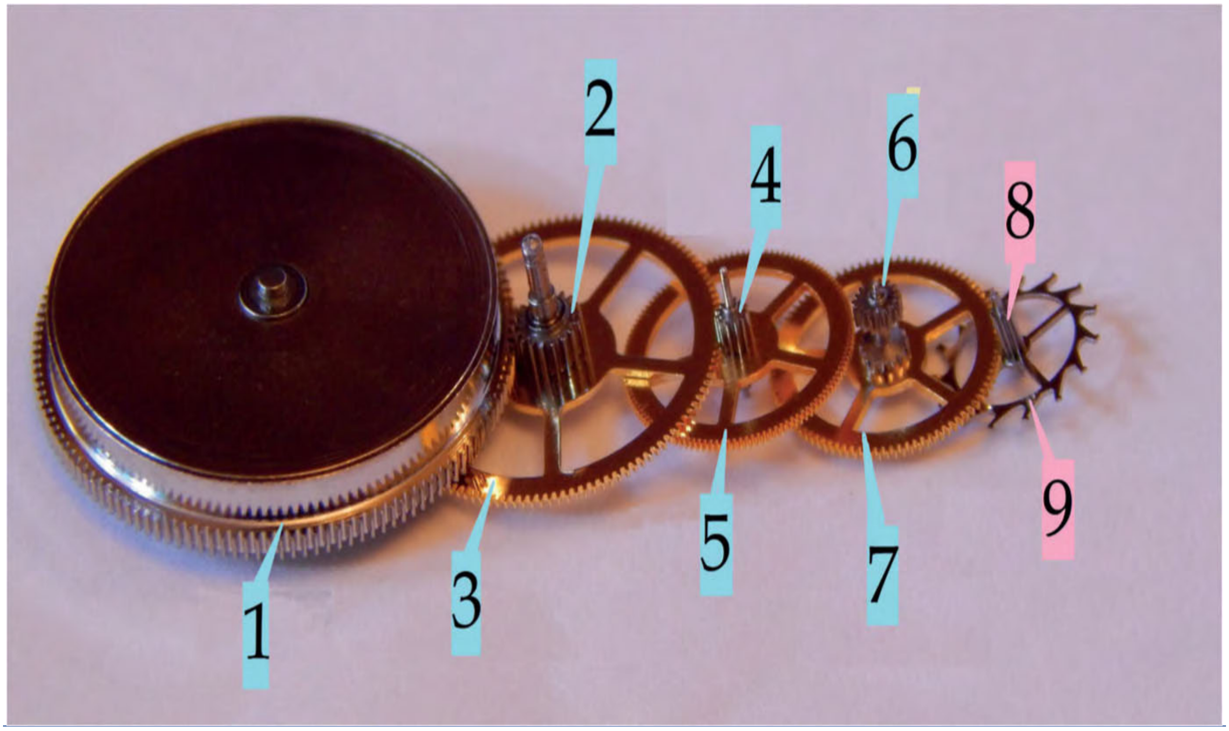


Fig. 166: (1) Barrel. (2) Centre wheel pinion. (3) Centre wheel. (4) Third wheel pinion. (5) Third wheel. (6) Fourth wheel pinion. (7) Fourth wheel. (8) Escape wheel pinion. (9) Escapement.

There are two types of gear found in a watch: wheels and pinions.

Wheels

Normally wheel gears are gold coloured or brass. They have a number of teeth ranging from fifteen to a hundred and twenty (approximately). Wheels are the drivers in a watch gear train.

Each wheel normally drives a smaller gear called a pinion (the driven, or slave gear). The tips of the teeth are shaped like a bishop's hat, which sits on top of a straight column. The whole tooth roughly resembles a human canine tooth (hence the name 'teeth').

Pinions

Pinions are typical in watches and the number of teeth ranges from six to fifteen. They are made from hardened steel and are known as the driven gears (that is, driven by a wheel). The teeth are known as *leaves* as they resemble willow leaves or daisy petals; they have round tops and the sides point to the centre of the pinion, meaning that each tooth is slightly 'V' in shape. When a pinion is driven by its mating wheel, the wheel's teeth push on the flanks (sides) of the leaves. This means that only a small part of the pinion leaf comes into contact with a wheel's tooth.

Don't be fooled into thinking that a watch contains a collection of random gears: each one is specifically designed to do a particular job. They interact with each other in the following way: the barrel, with its main spring, rotates on average about seven times in thirty hours. The barrel's teeth drive the pinion of the centre wheel, making it rotate at least twenty-four times in twenty-four hours. This is to rotate the minute hand, which is fixed to the end of the centre wheel's arbor via the cannon pinion.

The centre wheel then drives the third wheel by its pinion, and the third wheel drives the fourth wheel's pinion. This wheel is sometimes used to drive a seconds' hand, with an extension of the fourth wheel's arbor projecting through the watch's dial and fixing a hand on its end. This wheel rotates once every sixty seconds. The fourth wheel then drives the escape wheel's pinion, which rotates the escape wheel to push the pallet, which in turn impulses the balance wheel.

The watch we are working on makes 18,000 ticks or beats per hour, where each tick is an impulse or a push given to the balance wheel to keep it in motion.

The barrel and the centre wheel pinion control the number of hours a watch will run (known as duration). The rest of the gear train controls the speed at which the hands turn, and the number of ticks (beats per hour) the watch runs at.

If you look at your watch, you should be able to see a large gear at the centre, and if you look closely you will be able to see the shape of the teeth. If you have ever looked at any gear teeth in a mechanical device, you may notice that they are slightly different. This is because gearing in the world of horology (the study of time) is quite unique.

TOOTH SHAPE AND GEARING TERMS

It is important to understand why teeth are the shape they are, so that you can easily spot when there is a problem with a gear or the gears in a watch. This could be due to poor manufacturing or wear. You also need to have an understanding of basic gearing for the day when you start thinking of making your first watch (or at least making a replacement gear for an antique watch).

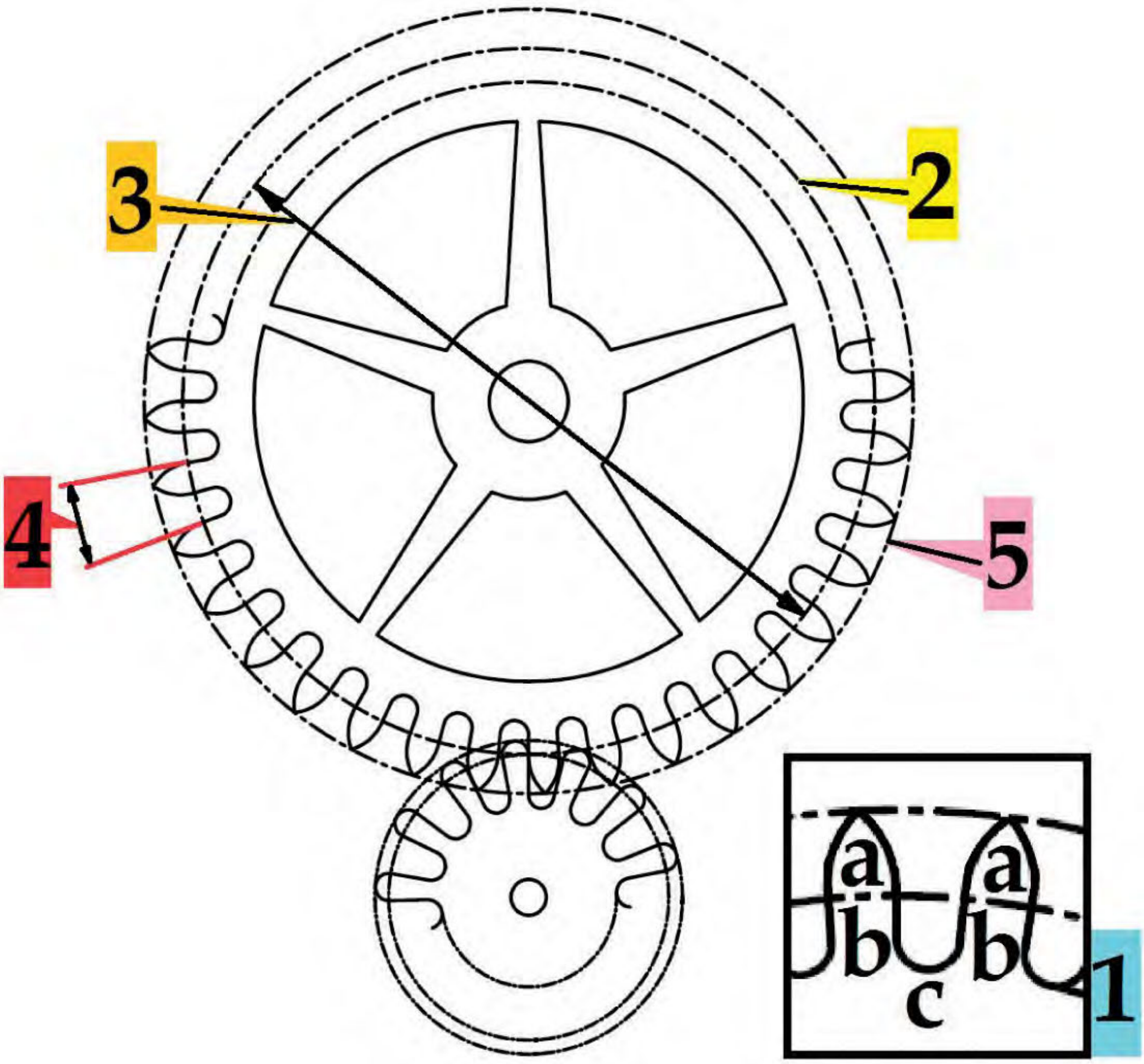


Diagram 15: (1A) Addendum. (1B) Dedendum. (1C) Root. (2) Pitch circle. (3) Pitch diameter. (4) Circular pitch. (5) Tip diameter.

The teeth of a watch are divided into six key parts:

Addendum: The curved portion of a tooth that resembles a gothic arch.

Dedendum: The straight sides of the tooth, below the addendum.

Root: The bottom of the gap of a tooth.

Pitch circle: The addendum and dedendum meet at this point.

Pitch diameter: The diameter of the pitch circle of a wheel or pinion.

Circular pitch: The distance of the centre of one tooth to the next, or the distance of two teeth tip to tip.

The addendum's shape is taken from three geometrical curves, which are as follows:

Involute: The most common type of gear tooth form found in the mechanical world, and this shape has considerable strength. It is normally used when gears rotate at both high speed and high torque. The involute form comes from a geometric curve drawn with a line that has been wrapped round a circle. The involute curve is the path mapped by the end of the line as it unwinds round its circle. To give this tooth form added strength, a small portion of the tip is cut off. This has the disadvantage of increasing the friction, but improves the strength at high speed as the tip of the tooth is the most delicate part.

Cycloid curve: This form is based on a fixed point on a cylinder that is rolling along a flat surface. The curve is the path traced by the fixed point as it rolls without slipping.

Epicycloid: This form is based on a fixed point on a cylinder that is rolling on the outside of a larger circle, and the curve is the path traced by the fixed point as it rolls without slipping.

If you take a segment of one of these three curves and make a mirror image of it, this will give you the tip of a tooth and will resemble the shape of a gothic arch or a bishop's hat.

The next geometric shape defines the dedenum, the lower portion of the tooth. This is really the odd one out, as the path traced out by the geometric shape is a straight line, and because this is for the flanks of a tooth, it is rather pointless, except that it proves that the geometry works.

Hypocycloidal: This is based on a fixed point on a cylinder that is rolling on the inside of a larger circle, and the straight line is traced by the fixed point as it rolls without slipping.

Unfortunately, in the world of horology there isn't one geometric curve that will apply to all gearing, as all the curves have advantages and disadvantages. These are dependent on the size or number of teeth needed on that gear.

In horology, the ideal scenario is when one tooth rolls over another, rather than sliding over each other. This rolling action minimizes friction and wear. However, this is seldom achieved, as inevitably some sliding action occurs between the teeth as they engage and disengage.

Some curves will give as close to a rolling contact as is possible; others will provide greater strength. To standardize and reduce the number of cutters used for cutting wheels, manufacturers use a mixture of the three curves and apply the best one for the job. Again, this is dependent on the size of the wheel/pinion, the number of teeth, and the amount of force in the gear train. The manufacturers will assign a module number to the cutter used when cutting the wheel or pinion that is required. There is a calculation to work out which module suits the gear you are to cut, by dividing the pitch diameter by the number of teeth.

Correct depth: In order for a smooth transmission of the mainspring power, its energy must flow smoothly from a wheel to its pinion with as little friction as possible. To ensure this, the tooth profile must be correct and provide the best rolling contact possible with its engaging pinion. Secondly, the distance of mesh (depth) between mating gears must meet on the pitch circles of both wheel and pinion. There should also be sufficient backlash (slop or rocking movement) between teeth to prevent the two gears from binding.

Deep depth: This describes wasted energy due to the teeth binding, caused by little or no backlash between a wheel and pinion.

Shallow depth: This means that there will be greater backlash between a wheel and pinion causing wear on the flanks (sides) of the tooth. It is commonly seen as little dimples on the surface of the pinion where contact takes place, and what I call 'train tracks'.

Understanding Depth Tolerances

Note that in modern watch repairing the tooth profile isn't much of a concern, and the depth should also be correct upon manufacturing. So why do we need to know? It's important to understand what the tolerances are, as from time to time you will be presented with a watch that has a gearing problem caused by wear, caused by possible neglect, and this knowledge will help you resolve and locate the problem.

It’s also important to understand all the disciplines of gearing when it comes to replacing bushes or jewels, and more so when it comes to modification when an exact replacement cannot be found. An example would be when a barrel bridge needs to be replaced and a new bridge is no longer available. This is a problem that is becoming more common, and arises because the worn bearing is now off centre. If you were just to enlarge the hole, this would automatically change the depth between the barrel and the centre wheel pinion. To correct wear you will first have to re-line the hole to bring the two gears to the correct depth.

This may be the dullest subject, but understanding it will only make you the better for it, in the end!

26. PIVOTS AND ARBORS

ARBORS

An arbor is the non-bearing surface of the axle of a watch, normally found with two gears, one cut into the arbor and one mounted along its surface. This normally sits in between the plates of a watch.

Arbors are made from hardened steel. By hardening, we mean the steel has been heated up to a cherry red colour (about 900°C) and flash cooled in oil or water; this process makes the steel very hard and brittle at this point. To make it less brittle and slightly more flexible, the steel then undergoes *tempering*, whereby the metal is heated again to a temperature of 300°C to relieve the stresses in the metal. This leaves it more flexible but hard enough to take a high polish. As the steel is heated to this temperature, its surface changes colour until it reaches a dark blue. (If you have ever owned a motorbike you may have noticed parts of your exhaust turning yellow, brown or blue: this is caused by heating at these particular temperatures).

Modern manufacturing methods are somewhat more complicated than this, but you should get the general idea from this description.

Staff: This is an alternative name given to an arbor that doesn't have a gear mounted on it. A staff is commonly found on pallets and the balance wheel.

PIVOTS

A watch's wheel arbor or staff has two pivots, one on each end of the arbor. These are normally two thirds smaller in diameter than the arbor itself. The waisted part of the arbor rotates in the jewelled bearing. They are highly polished to keep friction low when they rotate or are subjected to the thrusting forces of the mainspring.

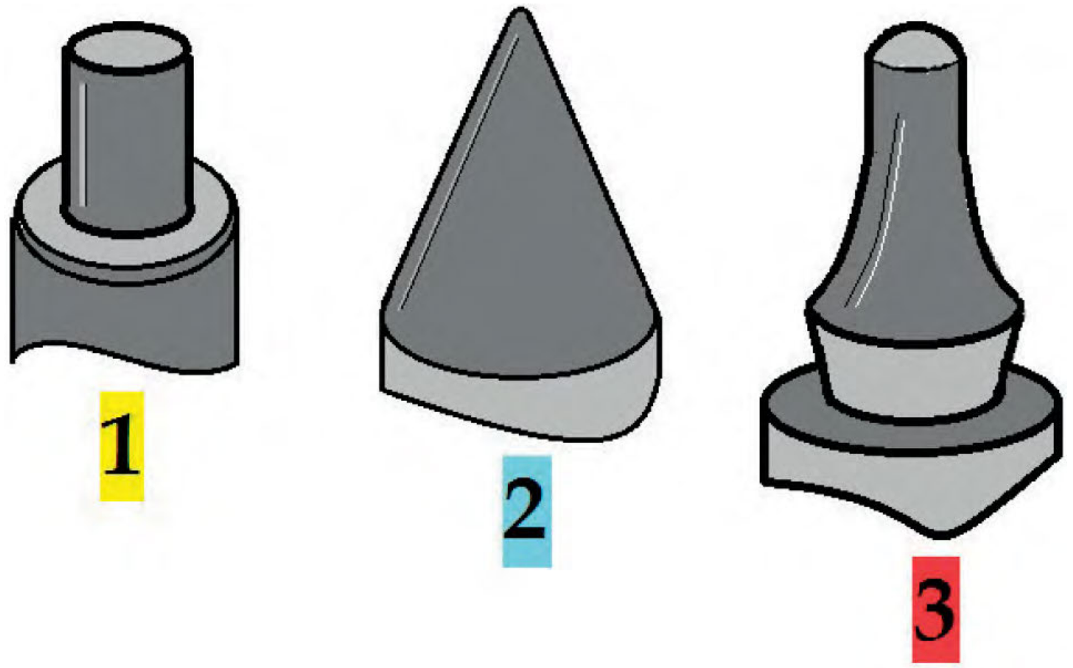


Diagram 16: Types of pivot: (1) Straight pivot. (2) Cone pivot. (3) Conical pivot.

Types of Pivot

Standard straight-shouldered pivots: These are used in a gear train for the barrel/centre wheel/third wheel/fourth wheel/escape wheel/pallet arbor. They are found in clocks as well as watches, and are the most common type of pivot.

Cone pivots: These are, as the name suggests, cone shaped, like a teepee. They are only used on a balance wheel in cheaper watches, as this type of pivot is cheap to make. This style tends to take up a lot of room, making the watch bulky.

Conical pivots: These are used on balances (and sometimes escape wheels) in high quality watches. The shape resembles that of a golf tee (an upside-down funnel shape).This shape adds strength to the middle of the pivot, making it ideal for a very thin pivot. A smaller pivot has a smaller surface area, causing less friction.

27. BEARINGS AND JEWELS

In horology we use a combination of brass/steel, bronze/steel and synthetic sapphire/steel. The synthetic sapphire/brass/bronze is used in the form of a bearing in which the steel axles of the gears rotate. Brass bearings, called ‘bushes’ (with a round with a hole at their centre), are normally only found in lower-grade watches or in watches where the jewel count is less than twenty-one jewels.

Sapphire bearings, called ‘jewels’, are synthetic (man-made). They are the most common bearing found in watches, as they have a stable temperature expansion to help prevent binding at high temperatures – unlike brass, which has a high coefficient of expansion (it expands a lot when heated).The surface of a jewel can be made super smooth by polishing during manufacture. As the material is nonporous, it is less likely that oil will creep out of the bearing. They can be manufactured accurately to a very small size, with a tiny hole. Their only disadvantage is that they are very brittle and can be easily damaged, especially when a watch is dropped.

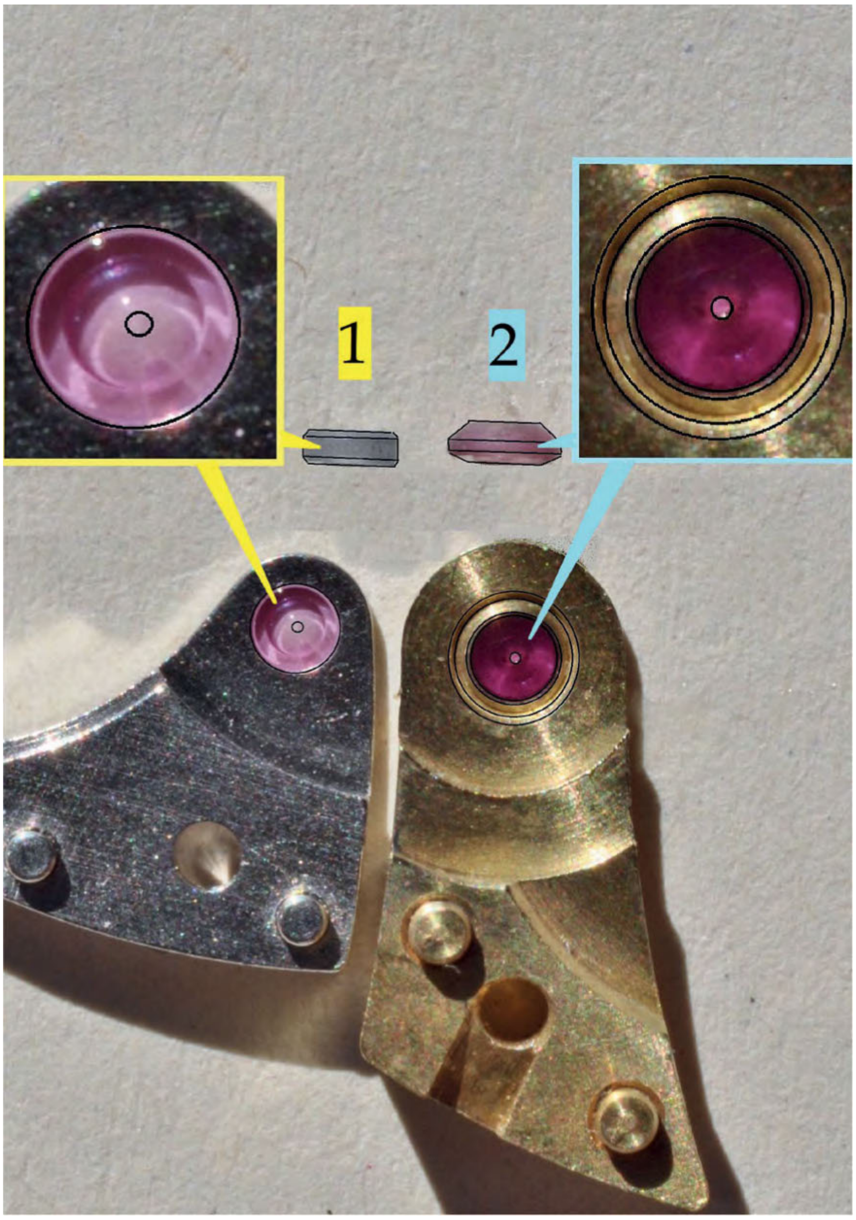


Fig. 167: Image 1: Pressed friction jewel. Image 2: Antique rubbed-in jewel.

There are two types of bearing jewels found in watches. The straight-sided *friction* jewel is the most common found in modern watchmaking. This jewel is a friction press fit into a hole in a watch's plate or cock. This hole is about .02mm smaller than the jewel.

The second type is the *rubbed-in* jewel. This is normally only found in watches made before the 1940s. Typically they resemble a flying saucer, and are fitted into the watch's plates in a recessed cup that has been milled into the plate. The jewel fits into the recessed cup, and excess metal around the top of the cup is rubbed over with a tool to form a lip to hold the jewel firm. This method is somewhat similar to a rubbed-over setting found in modern jewellery.

Friction jewels can easily be removed or replaced, or if necessary adjusted for end shake, with a tool called a jewelling tool. With a rubbed-in jewel you cannot adjust the end shake as they are pre-set in the factory.

There are three other jewelled parts found in a watch, again made of synthetic sapphire: the impulse pin and the two pallet stones.

SHOCK-RESISTANT BEARINGS

Earlier on in the book we looked at the balance wheel, when I hope you will have noticed that the pivots on the balance wheel were tiny (about .12mm in diameter – about the size of a strand of your hair), making the balance pivots very fragile. The balance wheel of a watch has a large mass compared to its pivots: this mass is needed to keep the balance wheel oscillating. The pivots are made small to reduce the friction in the balance's bearings.

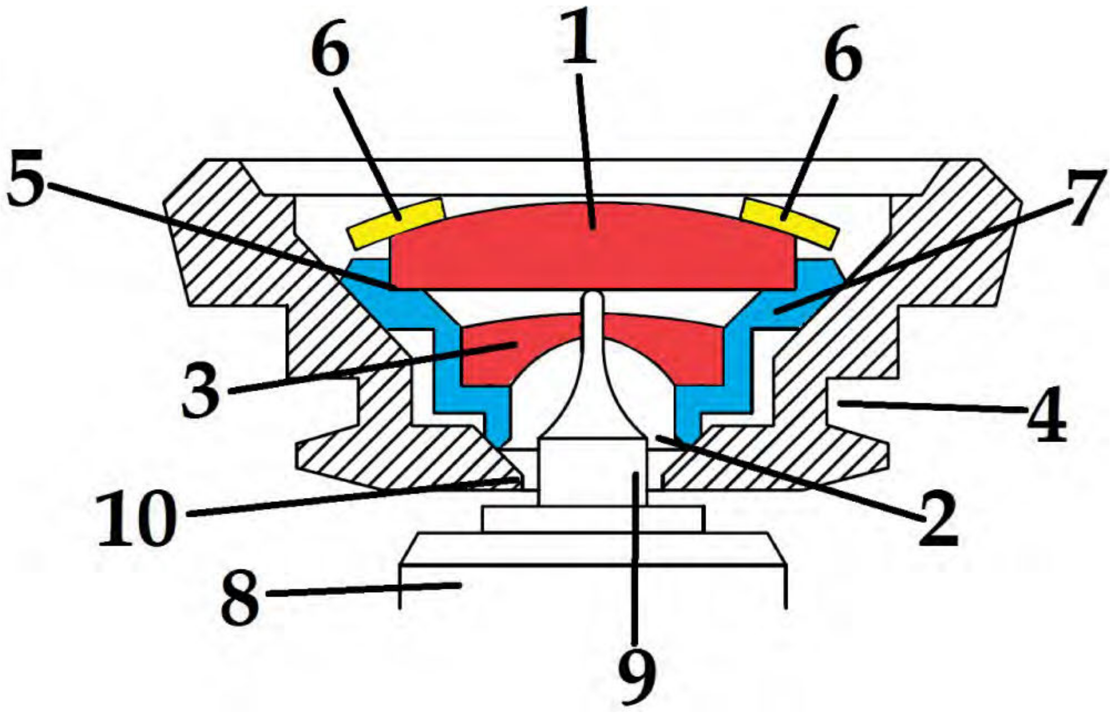
In daily life a watch is subjected to vertical and horizontal shocks, and with the oscillating mass that is the balance wheel there is a high risk of damage to the fragile pivots of the balance staff. The classic example of a vertical shock would be if you slammed your watch on a table in anger. This would probably result in one of the pivots smashing a hole in its end stone, or at the very least flattening the end of the pivot and increasing its surface area, causing the watch to run poorly as the friction has increased.

A classic horizontal shock would be its owner closing a drawer, heavy handedly. This shock, at a right angle to the balance wheel and its pivots, would result in one or both of the pivots being broken.

In the middle of the nineteenth century Abraham Louis Breguet was the first watchmaker to try and solve this problem with his little invention called the parachute. However, it wasn't until wristwatches caught on in the twentieth century that watchmakers really improved shock-resistant bearings. Wristwatches were more prone to shocks, unlike pocket watches, which were safe and sound in their owner's pocket. Wristwatches tend to be swung all over the place when being worn.

There are probably over fifty variations of shock-resistant bearings out there, each one of which has been tried and tested over the years. Today there are several in common use, and I will try to explain how the most common – from Incabloc – work.

Incabloc Bearings



The parts of an Incabloc bearing are shown in the diagrams.

Diagram 17: (1) Endstone. (2) Hole in the chaton. (3) Balance jewel. (4) Slot for the securing clip. (5) Recess for the end stone. (6) Retaining spring. (7) Chaton. (8) Balance staff. (9) Radial shoulder of the balance staff. (10) Hole in the bloc.

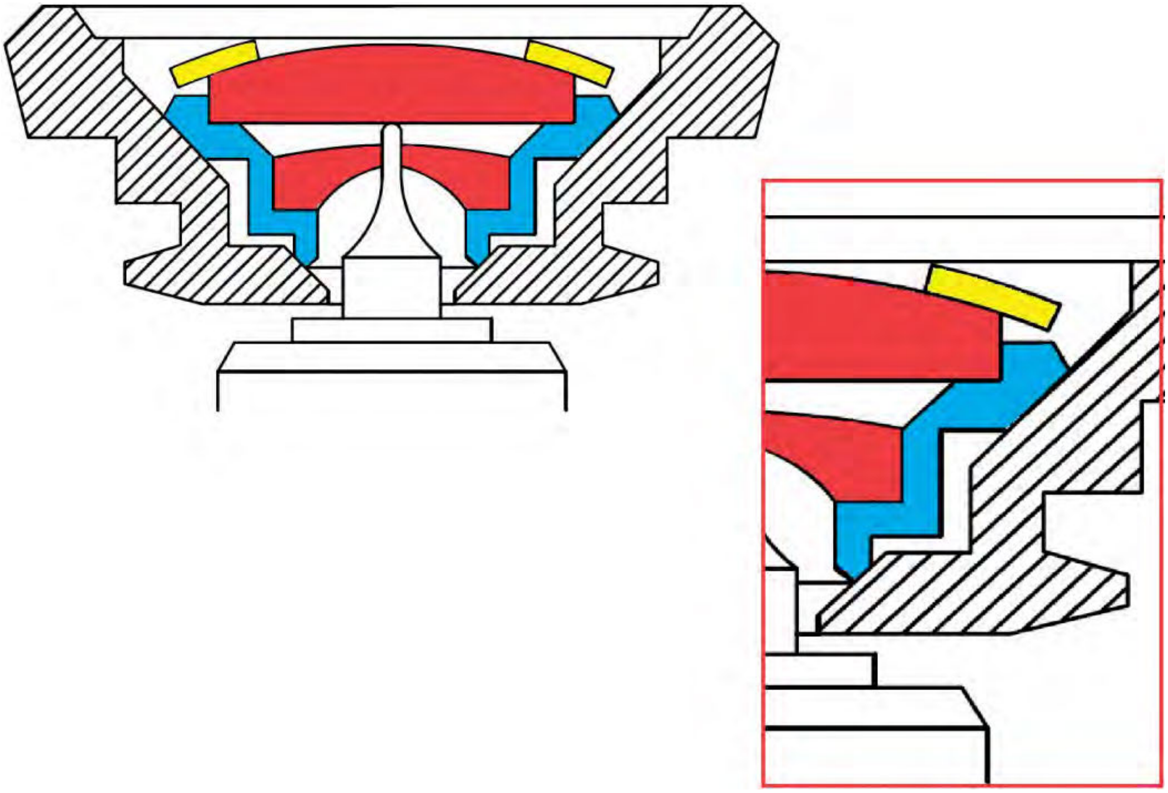


Diagram 18: Incabloc at rest.

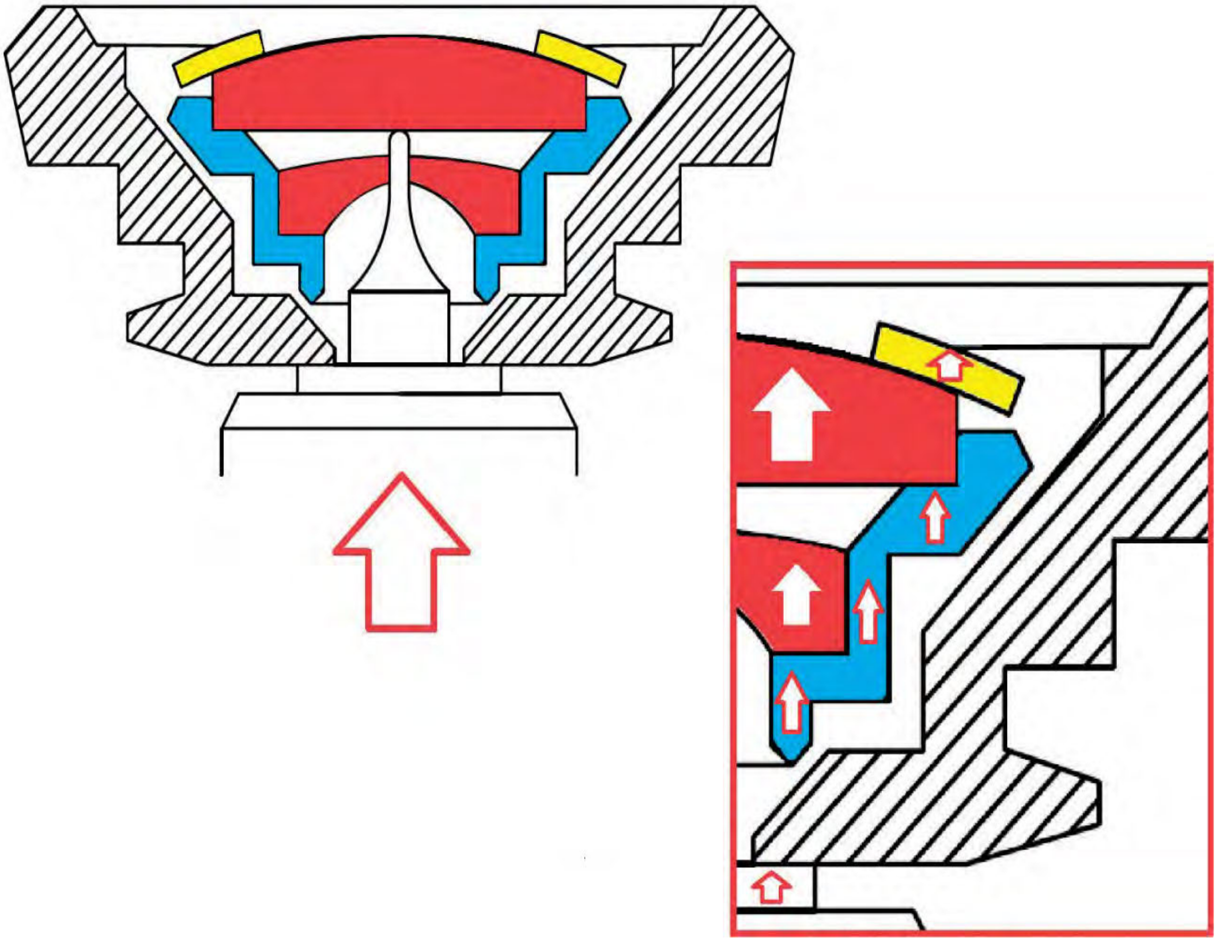


Diagram 19: Vertical or ‘up and down shock’.

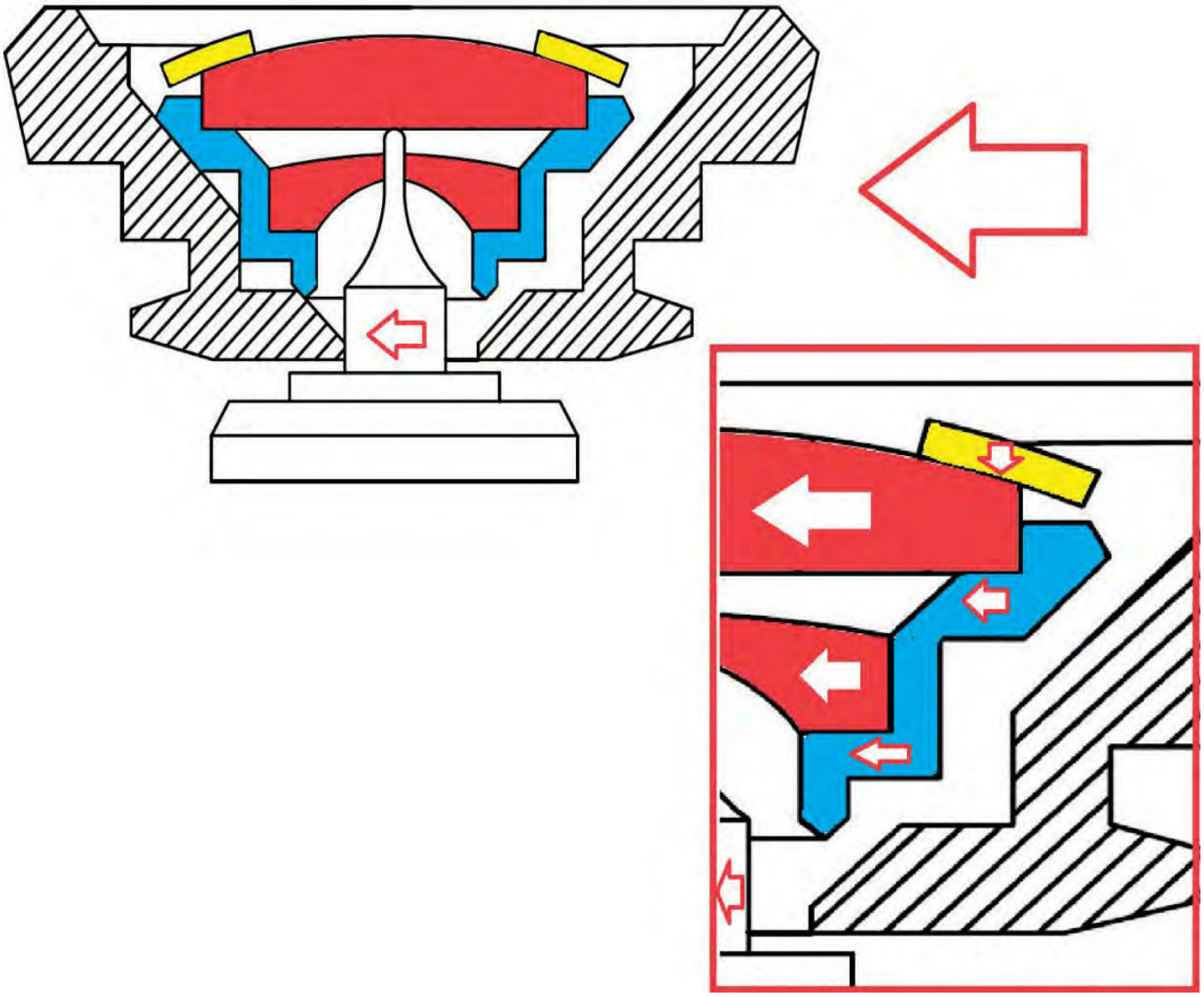


Diagram 20: Incabloc receiving a lateral (side) shock.

The chaton (7) is a cup into which the balance jewel (3) is pressed. The end stone (1) sits in its recess (5) like a lid in a jar. This is all kept in place and by the retaining spring (6) under tension. The balance staff (8) sits centrally in the bloc (10).

Incabloc bearings work in the following way. First, the balance staff is thrust towards the block. As this happens, the balance staff pivot pushes on the chaton and its captive end stone, making them both lift away from the bloc. The balance staff's flat shoulder eventually collides with the bottom of the block, bringing the balance staff's movement to a halt. The retaining spring then returns everything back to its central position, and the shoulder takes all the shock – so the shoulder of the staff again saves the day, and the pivot is left unscathed.

Most other shock bearings work in the same way. They can be identified by the shape of their retaining spring, though the overall design may differ slightly from bearing to bearing.

At the moment of impact, the balance staff is forced to move sideways. This is caused by the kinetic energy of impact (just like a passenger in a crashing car). The most important thing that happens as the balance and its staff move is that the chaton moves sideways and rides up the side of the bloc. This is caused by the fact that both the chaton and the bloc have stepped, sloped sides, and the retaining spring flexes upwards allowing the movement to happen. The spring tries to push the bloc back to its resting position, causing dampening of the shock. The balance staff continues to move sideways until the radial shoulder of the staff collides with the hole of the bloc, thus taking the brunt of the shock. This shoulder is considerably thicker than the pivot and far less likely to break. The spring then returns everything back to its central resting position.

28. STRIPDOWN AND REASSEMBLY OF A WATCH

To remove the train bridge you will have to remove all the other components that you have previously removed. This will be a complete disassembly. As this will be your first time I would recommend grouping the parts together with their respective screws in a segmented box, as the screws can be different lengths and shapes. If your watch is slightly different to the watch in the book, I would recommend that at each stage of the stripdown you take pictures with a digital camera, or possibly using your phone, in case you get stuck later on when reassembling the watch.

STRIPDOWN OF A WATCH

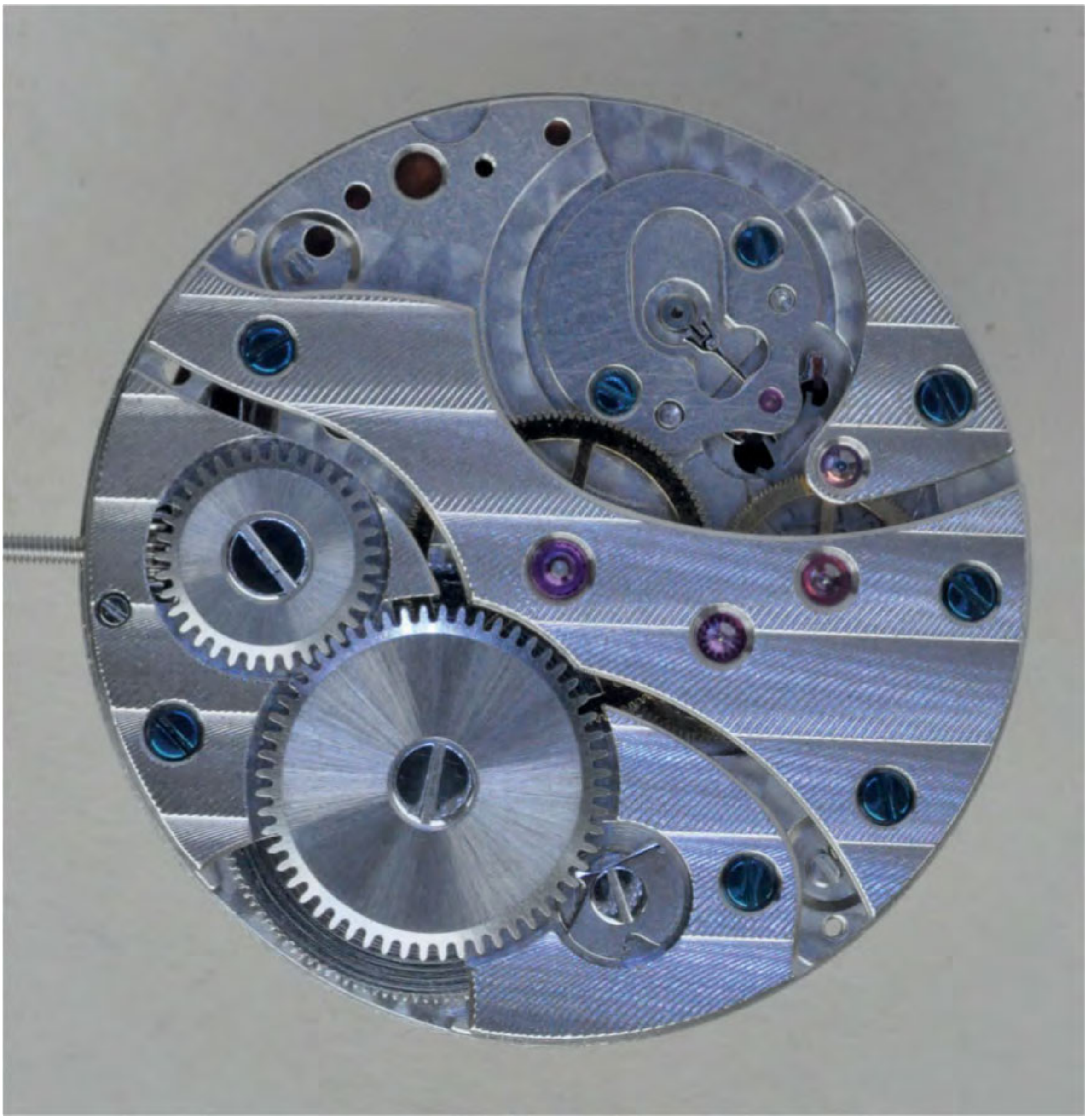


Fig. 168: Always remove the balance first.

1. Place the movement in a movement holder. Remove the balance wheel, as this is one of the most delicate parts in the watch. It is always good practice to keep it out of harm's way. Remember to turn it and its cock over to protect the pivots.

2. Let down the power of the mainspring by pulling back the click and letting off the power in a controlled manner, as previously described. This will protect the gears from a sudden release of energy from the spring during disassembly.

3. Remove the ratchet wheel (this will doubly make sure there is no energy left on the spring), followed by the upper crown wheel. Remember that the screw holding down the upper crown wheel has a left-handed thread.

4. Remove the movement from the holder, turn the watch over (dial side) and rest the movement flat on the bench. Remove the cannon pinion, followed by the complete removal of the keyless work and motion work. The reason for removing the keyless work now, rather than later, is so the winding pinion and clutch wheel remain in the movement, as the barrel bridge will prevent them from falling on the floor! Remove the return bar spring in a bag.

5. Refit the movement in the holder so that the train bridge and barrel bridge are again facing you. Remove the pallet bridge, and lift out the pallets.

6. Remove the screws holding down both the train and barrel bridges, and lift off both.

7. Lift out the wheels in the following order: barrel, centre wheel, fourth wheel, third wheel and finally the escape wheel.

REASSEMBLY OF A WATCH

When reassembling a watch I would first recommend picking out the four train gears and laying them out in front of you. Next, arrange them according to size. The gears in a watch train decrease in size the further away they are from the barrel. Remember that a wheel drives a pinion, so rotate them until the barrel drives the pinion of the largest gear (the centre wheel pinion).The centre wheel should now drive the pinion of the next larger wheel.

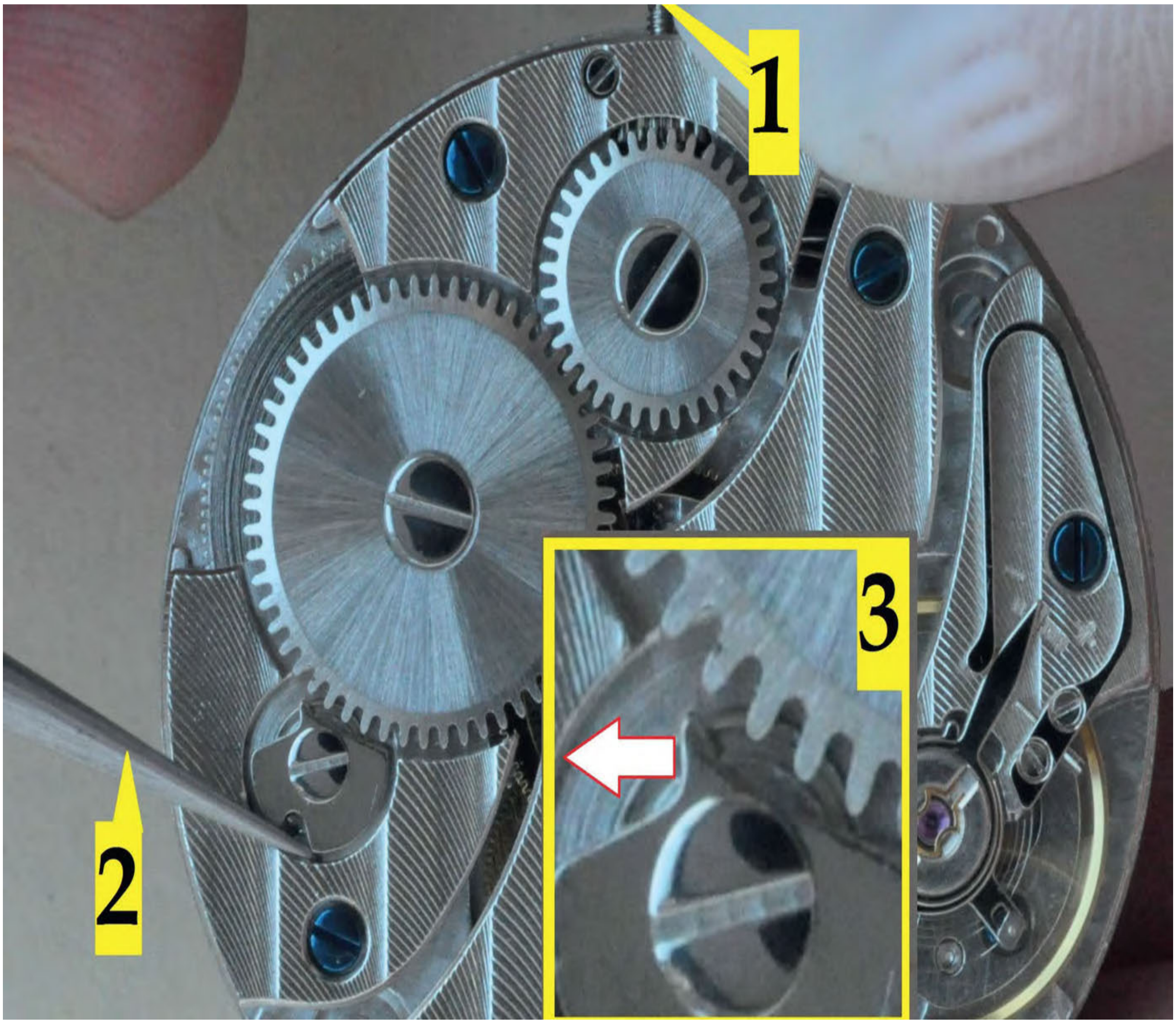


Fig. 169: Let down the power of the mainspring: (1) Rotate the winding button, so the click looks like image 3. Using tweezers (2), pull back the click (3).

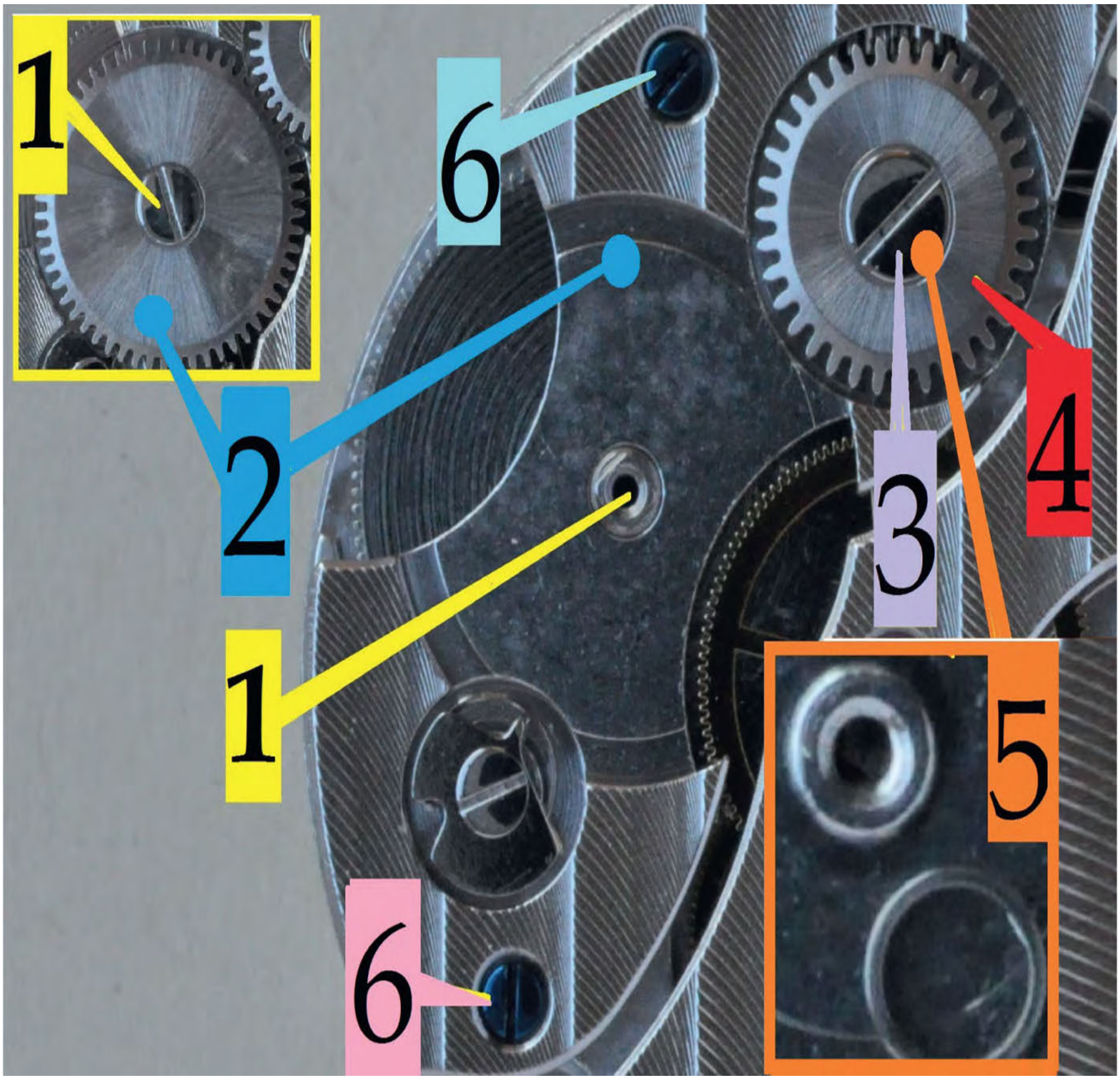


Fig. 170: Disassemble in number order.

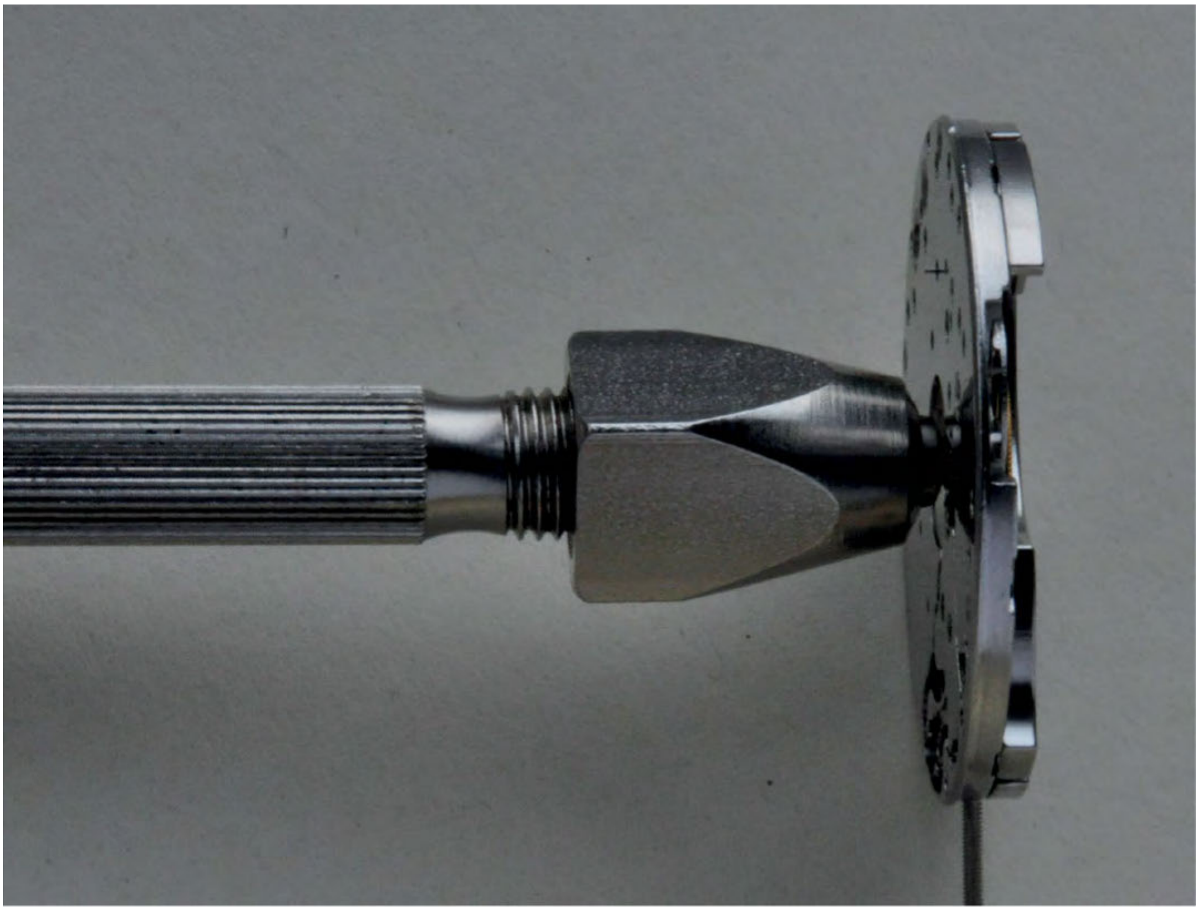


Fig. 171: Remove the cannon pinion using a pin vice.

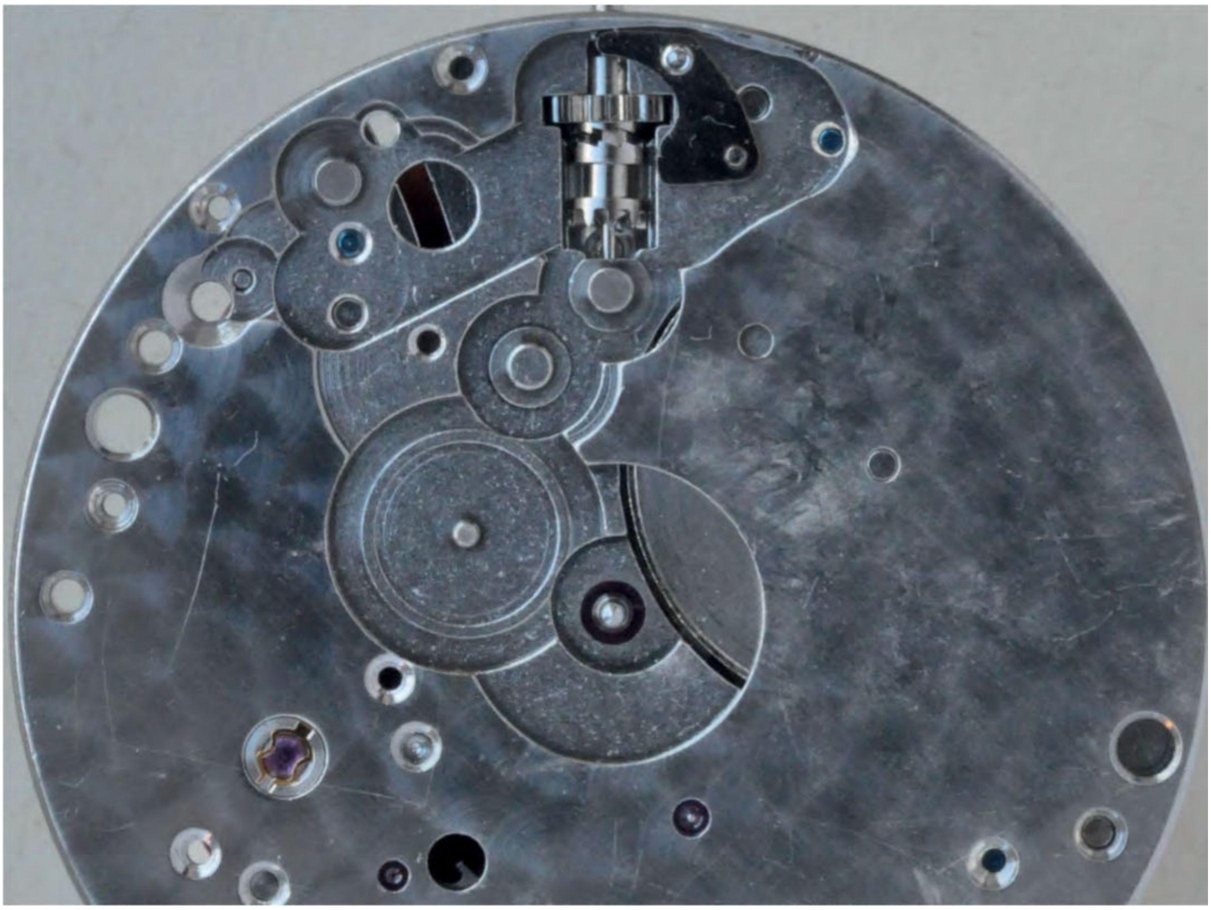


Fig. 172: Remove all the keyless and motion work.

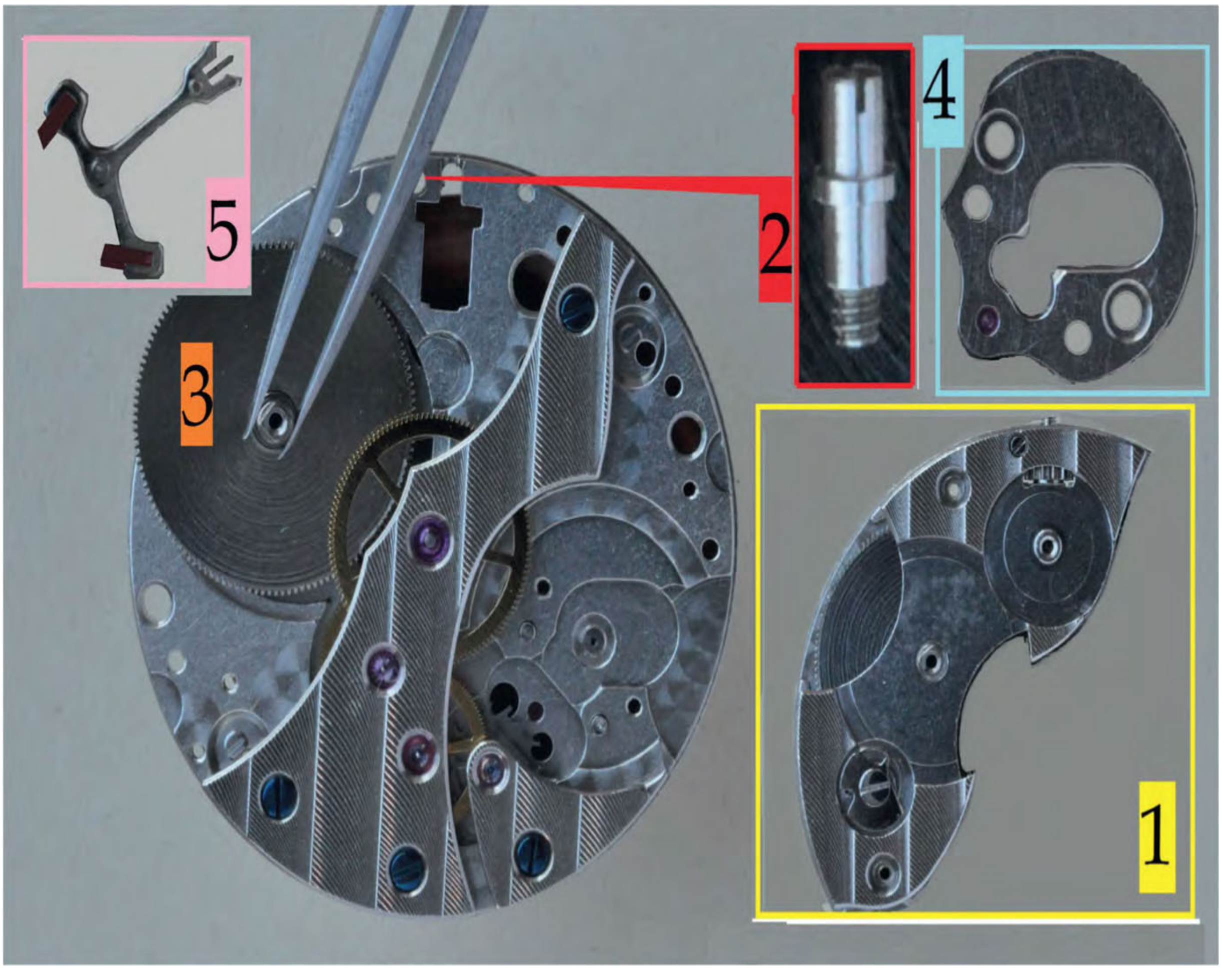


Fig. 173: Remove in number order.

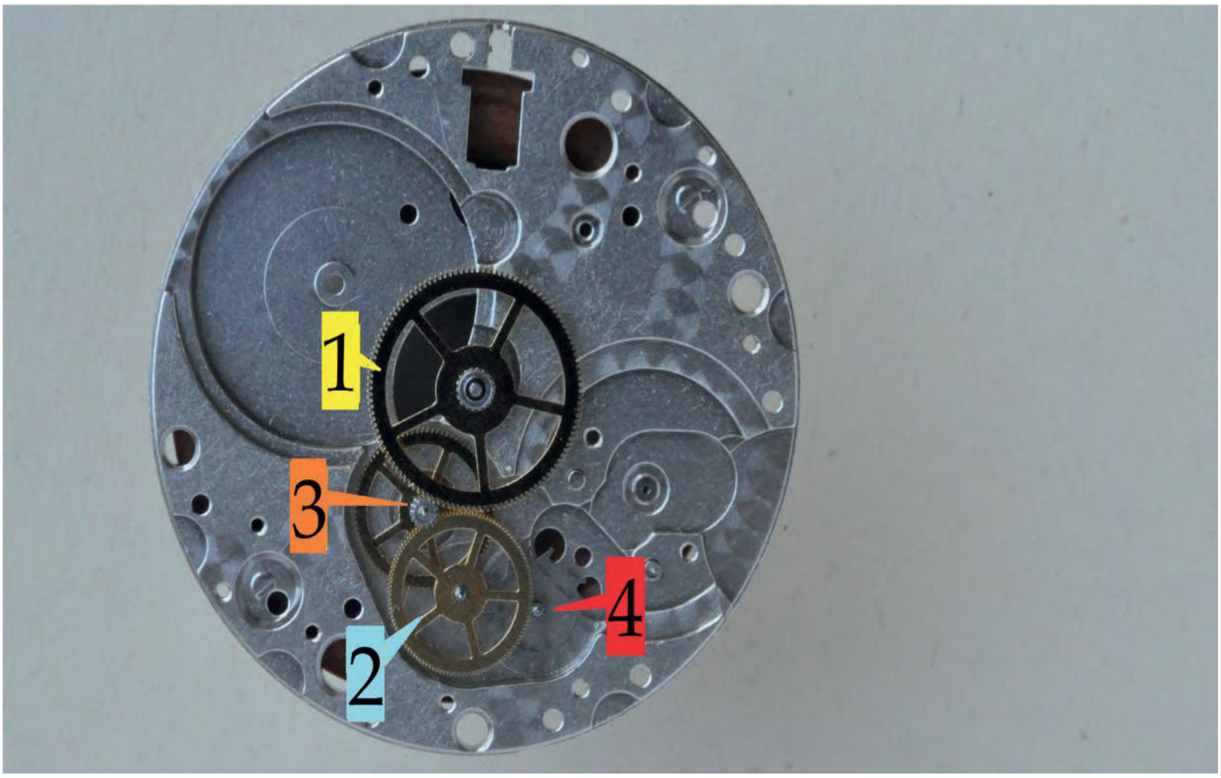


Fig. 174: Remove in number order.

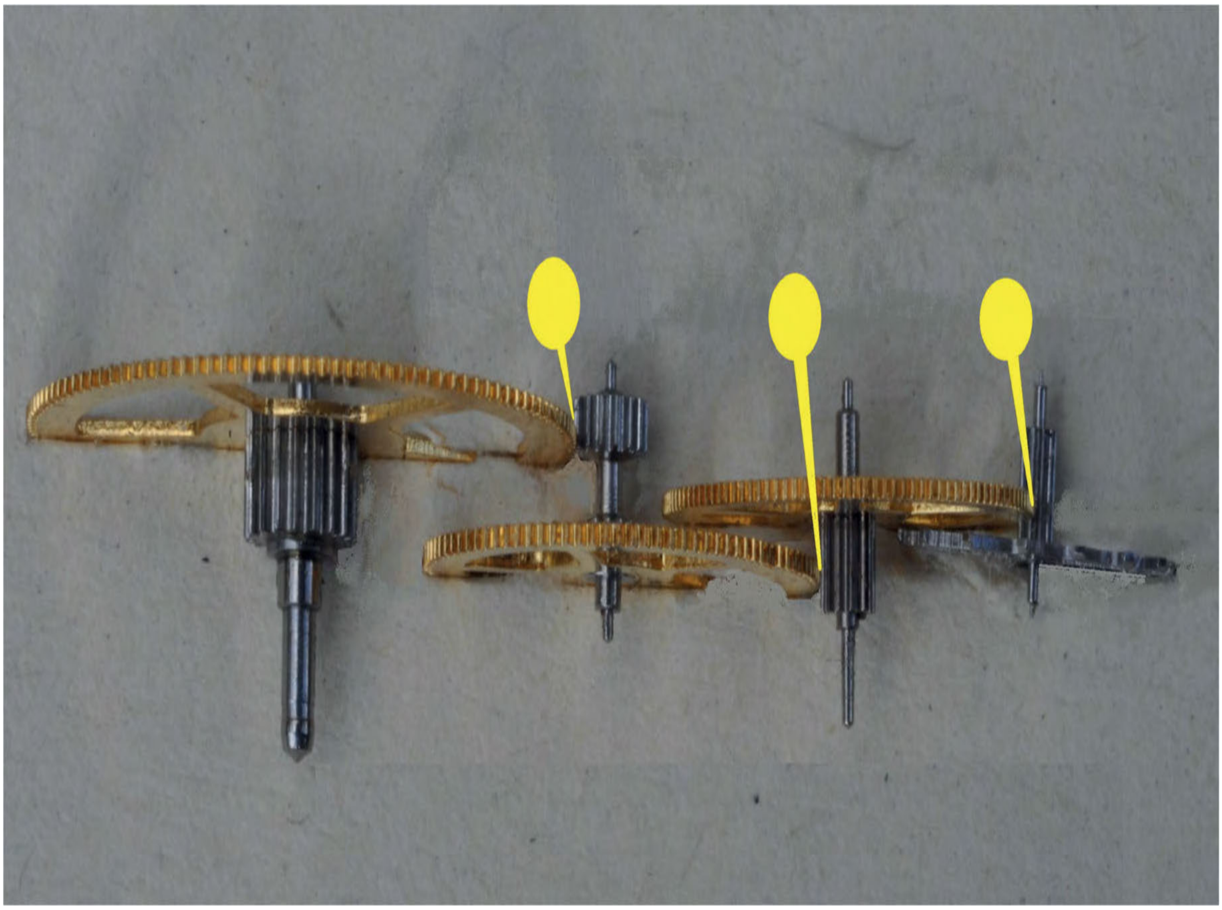


Fig. 175: Remember ‘a wheel always drives a pinion and the wheels decrease in size’.

To make this more difficult, you sometimes find that the third and fourth wheels can be a similar size. Identifying the fourth wheel can be easy, if the watch has a subsidiary seconds’ hand. If this is the case, the fourth wheel will have an elongated pivot for the second hand to fit on. Alternatively, the third wheel will have coarser teeth on the pinion. Once you have worked out the order of the wheels and the orientation, you can start fitting them back into the watch.

1. Fit the main plate in a movement holder. Fit the centre wheel in the centre hole, so that the longest pivot protrudes though the main plate to the dial side.

2. Next, fit the third wheel in the jewel hole next to the centre wheel. This wheel will normally tuck underneath the centre wheel.

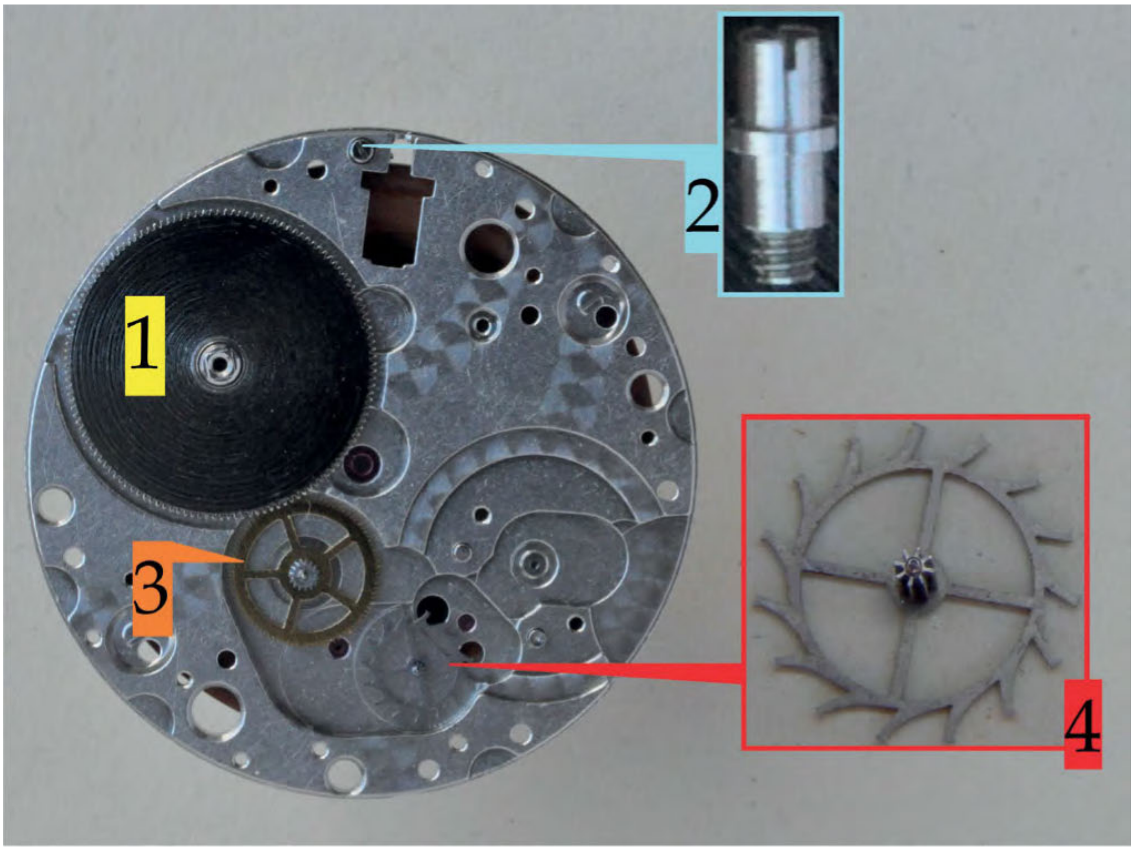


Fig. 176: Assemble in the following order: 1–4.

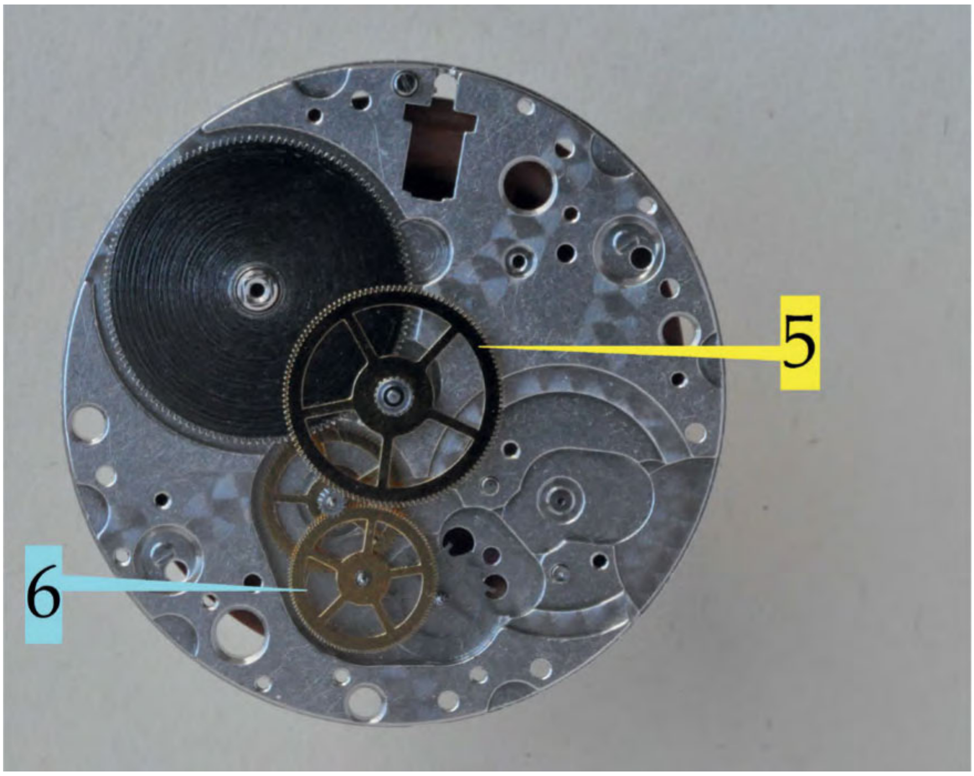


Fig. 177: Assemble in the following order: 5–6.

3. You now have to miss a step by fitting the escape wheel instead of the fourth wheel. This will fit into the second free jewel hole. The escape wheel will be oriented so that it is sitting at the bottom of its pinion.

4. Fit the fourth wheel between the third wheel and escape wheel, so that this wheel is in the same orientation as the centre wheel. If all is correct, all the brass wheels should be driving a steel pinion.

5. If your watch has a separate cock for the escape wheel, roughly position this on the main plate over the escape wheel, taking care to locate its two steady pins. Using a watch repairer's probe (or homemade version) in your left hand, apply light pressure to the top of the cock.

With your tweezers in your right hand, you are going to have to mate the escape wheel's pivot in its jewel hole. If you look though the jewel in the cock you should be able to see the tip of the pivot. This will help you work out which direction to move it. If you struggle to see the pivot, look at the escape wheel as a whole and you will probably notice it may look as if it is leaning, or not sitting level with the main plate.

Once the pivot is safe in the jewel hole, keep the probe on top of the cock. This will help prevent the pivot jumping out of the jewel.

Pick up the appropriate screw for the cock with your tweezers in your right hand, and dock the screw in the cock. Tighten it up with an appropriate size screwdriver, whilst all the time keeping pressure on the cock with the probe.

6. Roughly lay the train bridge in position, taking care to locate its two or three steady pins. Again, using the watch repairer probe in the same fashion as before, apply light pressure to the top of the cock. This time, apply pressure in the area of the centre wheel.

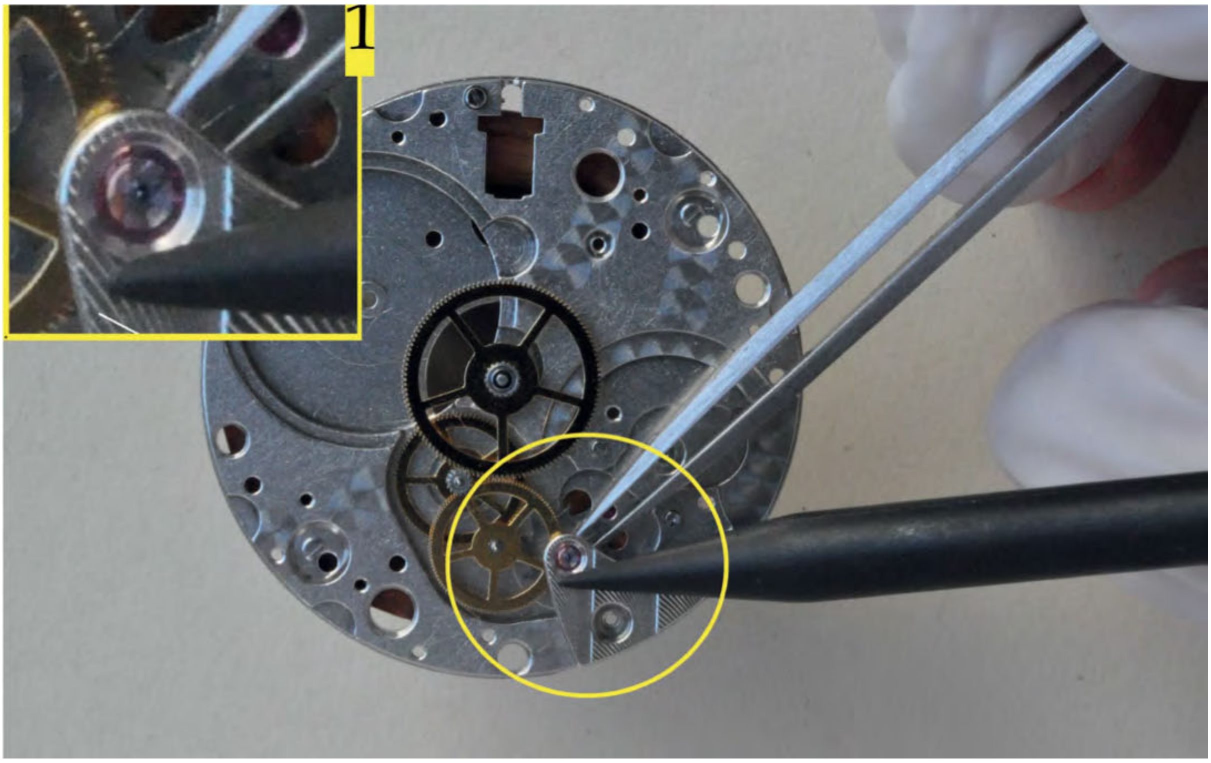


Fig. 178: Locating the escape wheel pivot into its jewel hole, using a watchmaker’s probe and tweezers.

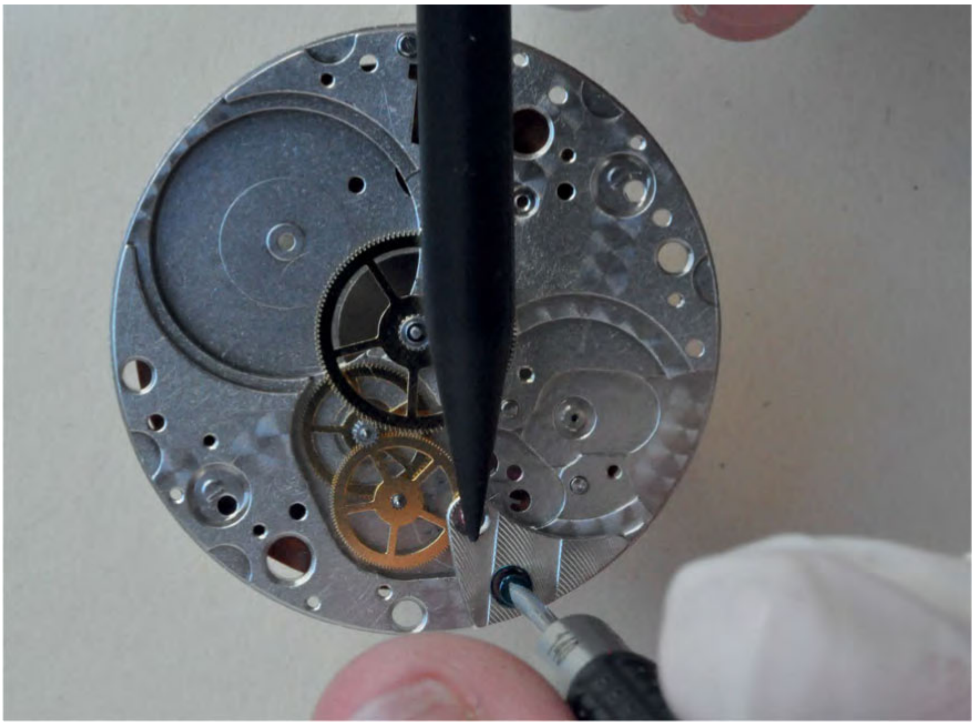


Fig. 179: During tensioning of the screw, remember to keep light tension on the escape wheel cock with the probe.

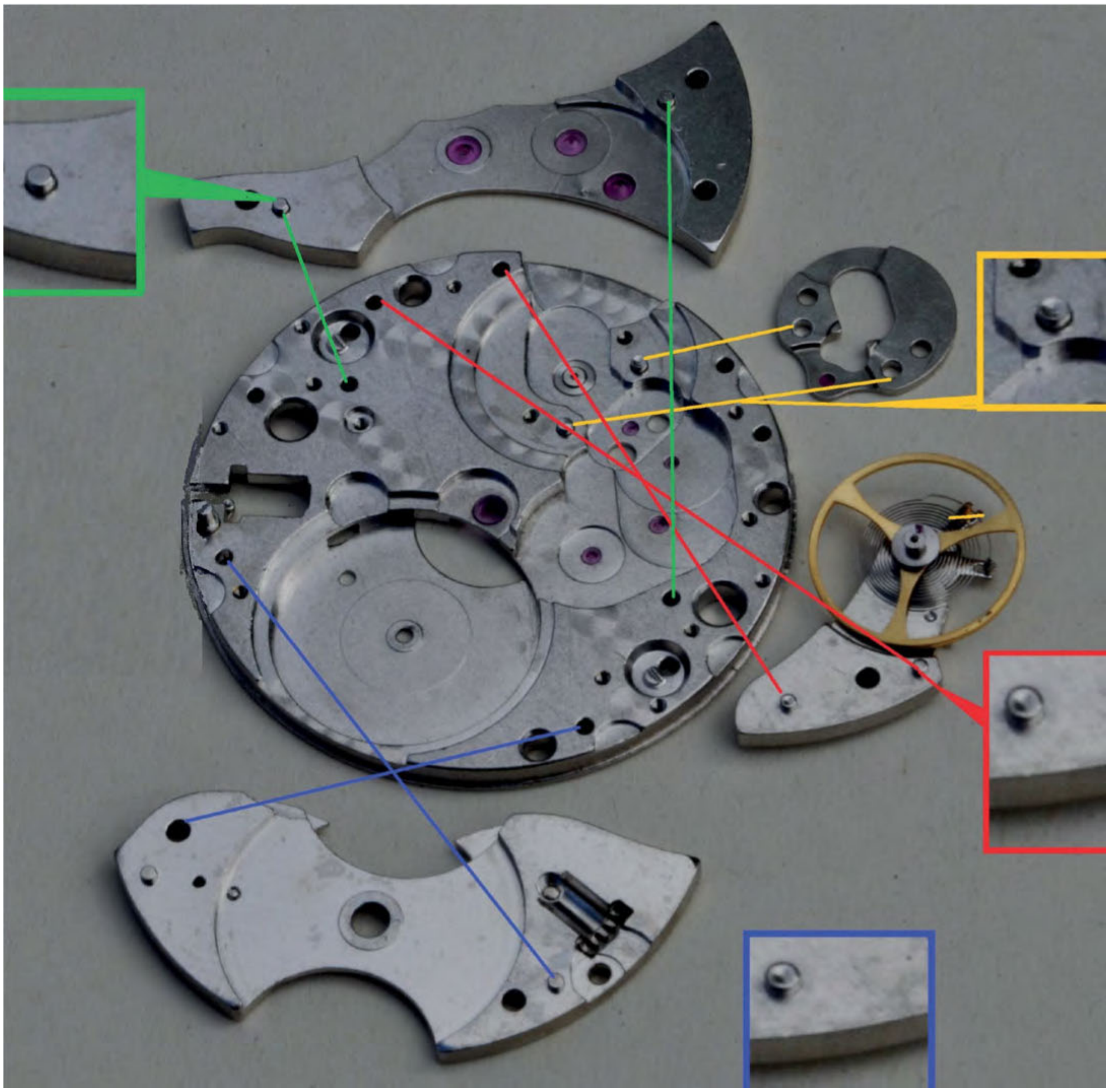


Fig. 180: A map of where the bridge and cock steady pin locate in the base plate.

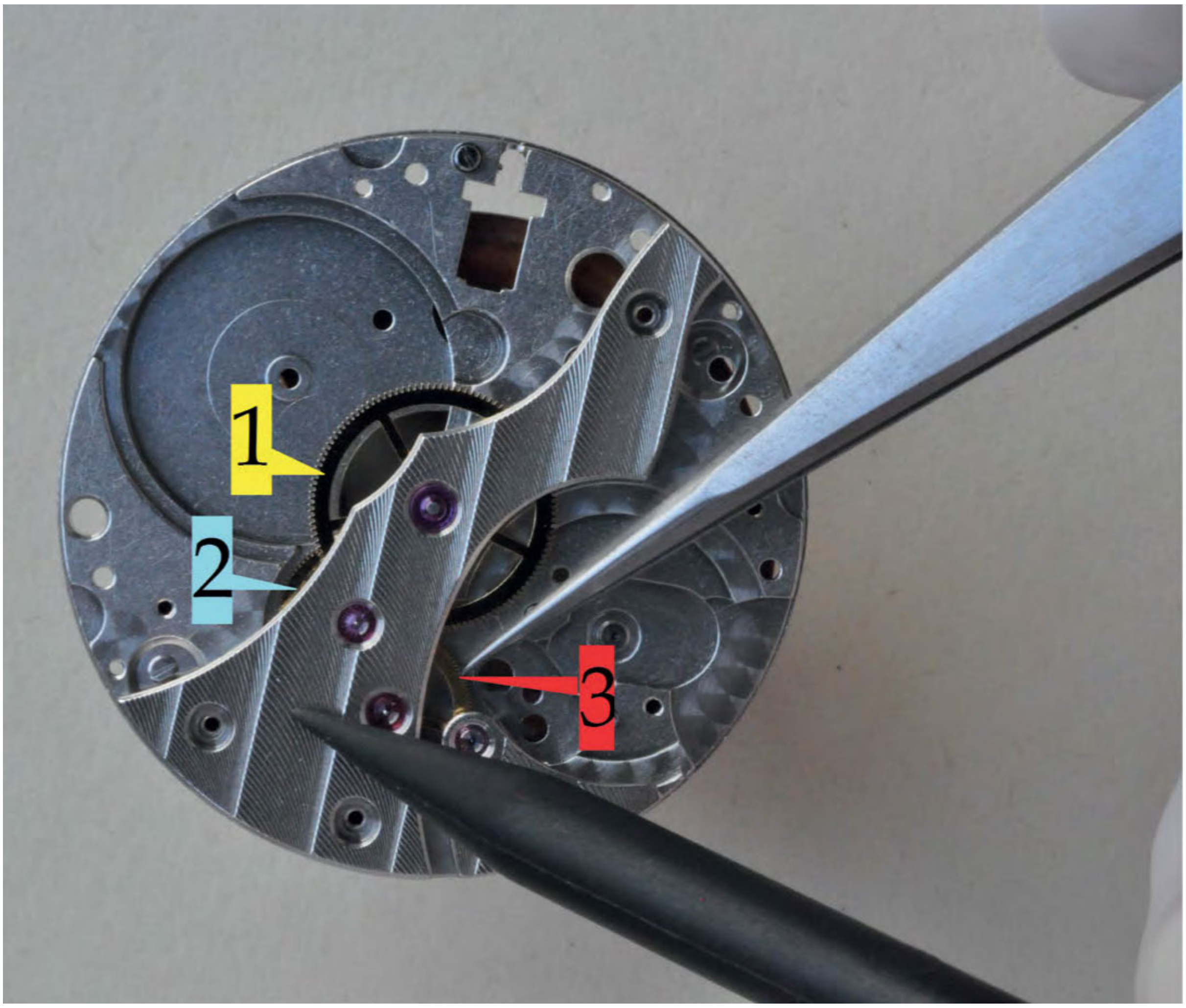


Fig. 181: Locate the pivots in their jewel hole in the numbered order.

First, locate the centre wheel’s pivot, followed by the third and fourth wheel’s pivot, again looking though the jewel holes.

If you are really having trouble, lower your head so you can see directly inside the movement and you may have a clearer view of the wheels. You may also find that you have to rotate the movement to gain a clearer view of the wheel you are trying to fit in its hole.

Once all the pivots are fitted in their holes, don’t be tempted to lift up the watch probe, as the pivots you have just fitted may jump out of their holes. Keep it in place until the screws are all fitted in the train bridge.

Tip: When you first tighten up the screws of a train/escape or pallet cock or bridge, it's a good idea to just lightly tension them. Then take a watch repairer's puffer or bellows and shoot a blast of air at the escape wheel. If all is well, the escape wheel should spin freely for about five seconds and come to a gradual stop. If the wheel fails to move, look at the jewel hole, as one of the pivots may have jumped out of its hole – but as long as the screws were only lightly tightened, hopefully this will have prevented it from snapping off. If all is now well, give the screw heads a final torque up, so they are nice and tight. You don't want a screw to work loose later on and foul up the works.

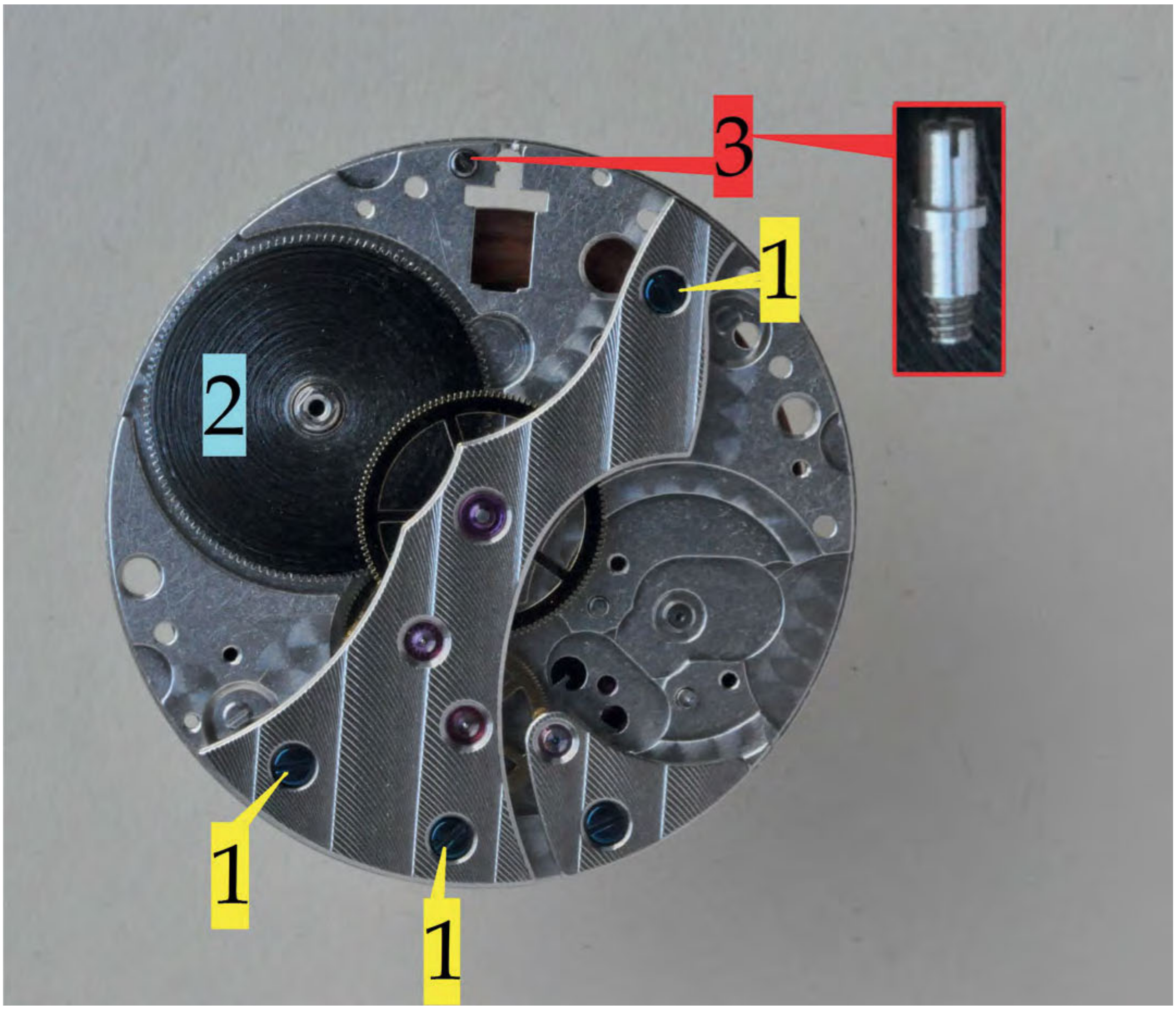


Fig. 182: Replace the train bridge screws (1). Tuck the barrel (2) under the centre wheel. Don't forget to fit the bolt screw (3).

7. Fit the barrel in the watch, making sure the hole in its arbor is facing upwards. This is the hole the ratchet screw fits into. You will find that you have to tuck the barrel under the centre wheel to fit it into its recess. Fit the bolt screw in its hole. This is normally just to the right of the large ‘T’-shaped cut-out next to the barrel. Refit the barrel bridge on the main plate and replace the screws.

Tip: It is good practice to look at the length of the train and barrel bridge screws, as one or two of them may be shorter than the others. If this is the case, they are normally fitted to either side of the bolt screw. If you fail to take note of the length of screws, one day you may break or foul up a lever or a wheel! If in doubt, always look on the opposite side and see if the screw extends too far out of its hole.

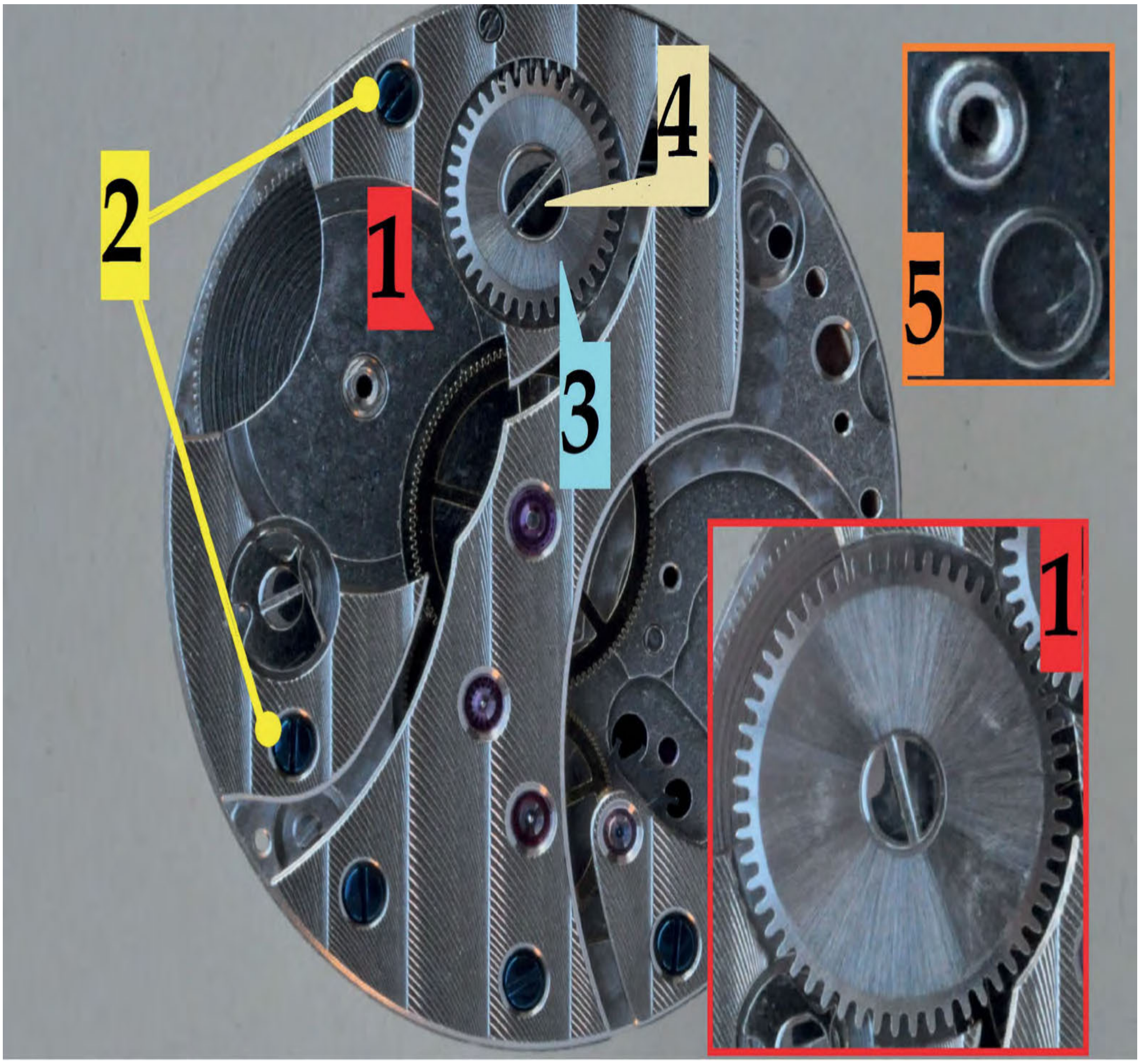


Fig. 183: Replace the winding gear in the numbered order.

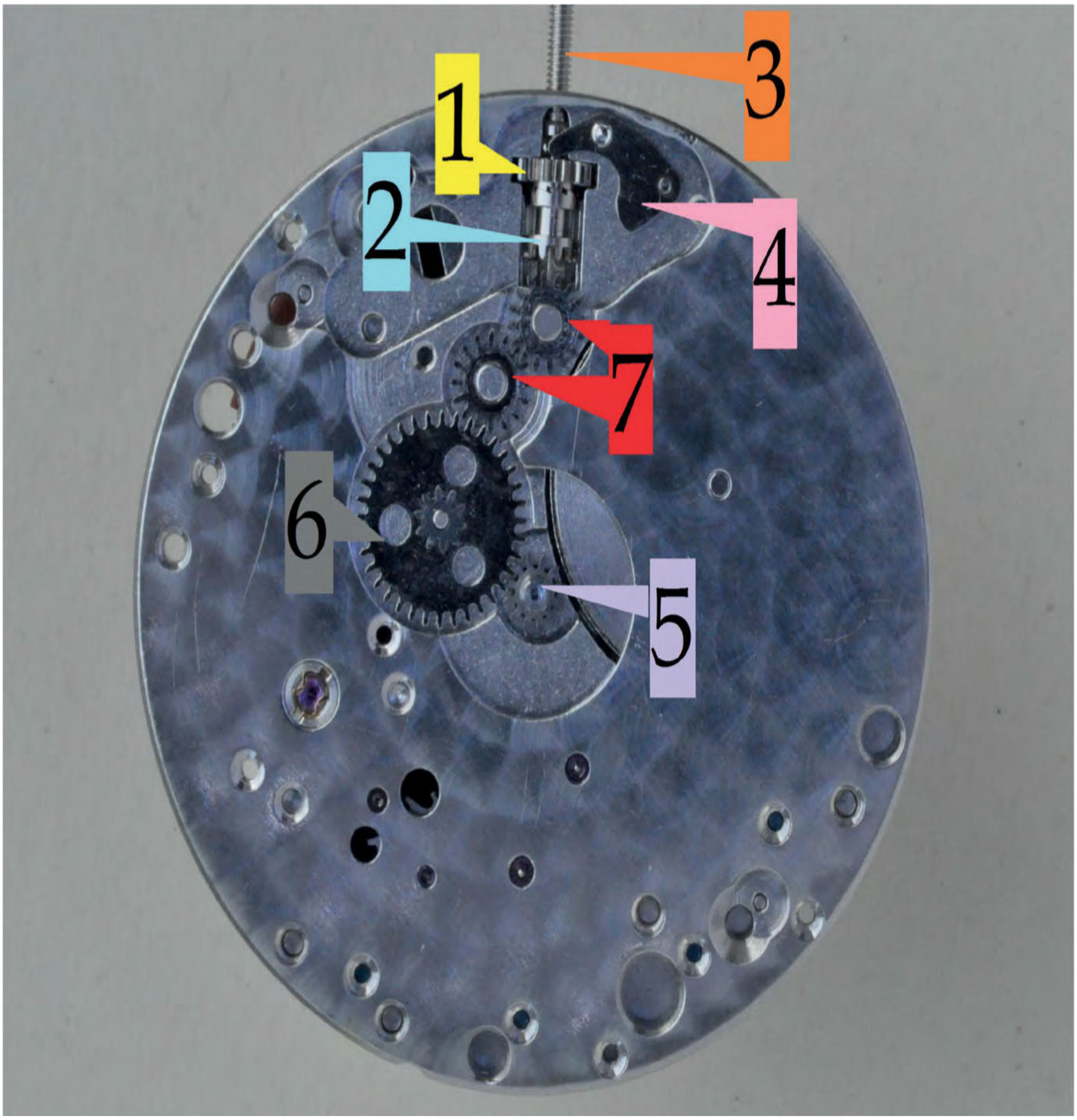


Fig. 184: Refit the keyless work and motion work in the numbered order.

8. Fit the upper crown wheel, remembering to fit its bush (little steel donut) first. Refit the upper crown wheel's screw. This will be one of the two large screws, but with the shorter left-handed thread (sometimes indicated by three slots on the head of the screw).

9. Turn the watch over and fit the cannon pinion, followed by the minute wheel and intermediate setting wheels. Drop in the winding pinion and sliding clutch. Slide the winding

stem into the main plate and locate the clutch and winding pinion on it. Fit the bolt piece, followed by the rest of the keyless work in the same manner as previously mentioned in the keyless work section.

10. You should be able to wind the watch now that the keyless work is fitted. If all is well, the wheels will spin freely. As they come to a stop, the wheels should recoil a few spins. If they don't, you may need to re-clean the watch, or you might have a bent pivot.

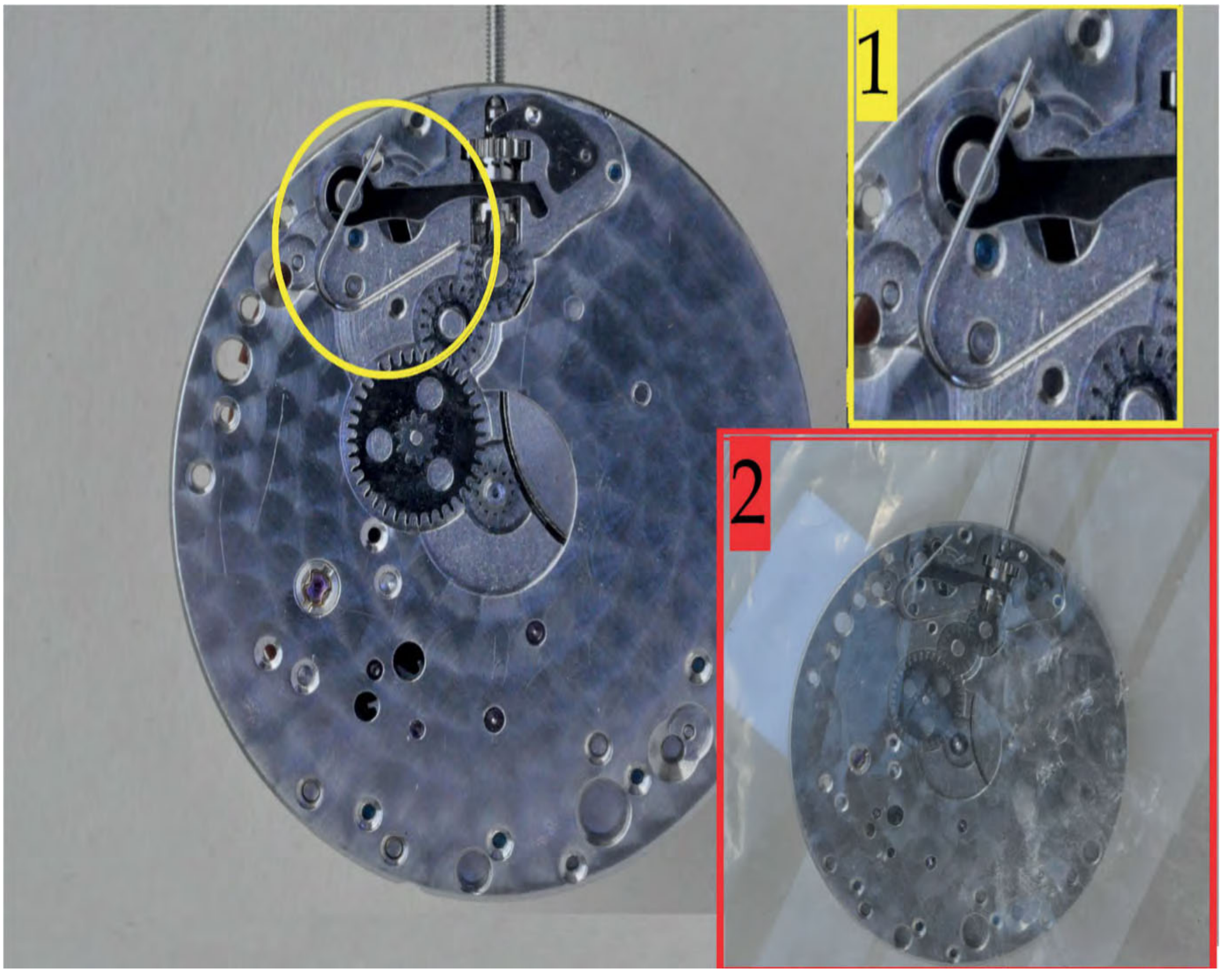


Fig. 185: Replace the return bar spring, ideally in a plastic bag to prevent it from escaping.

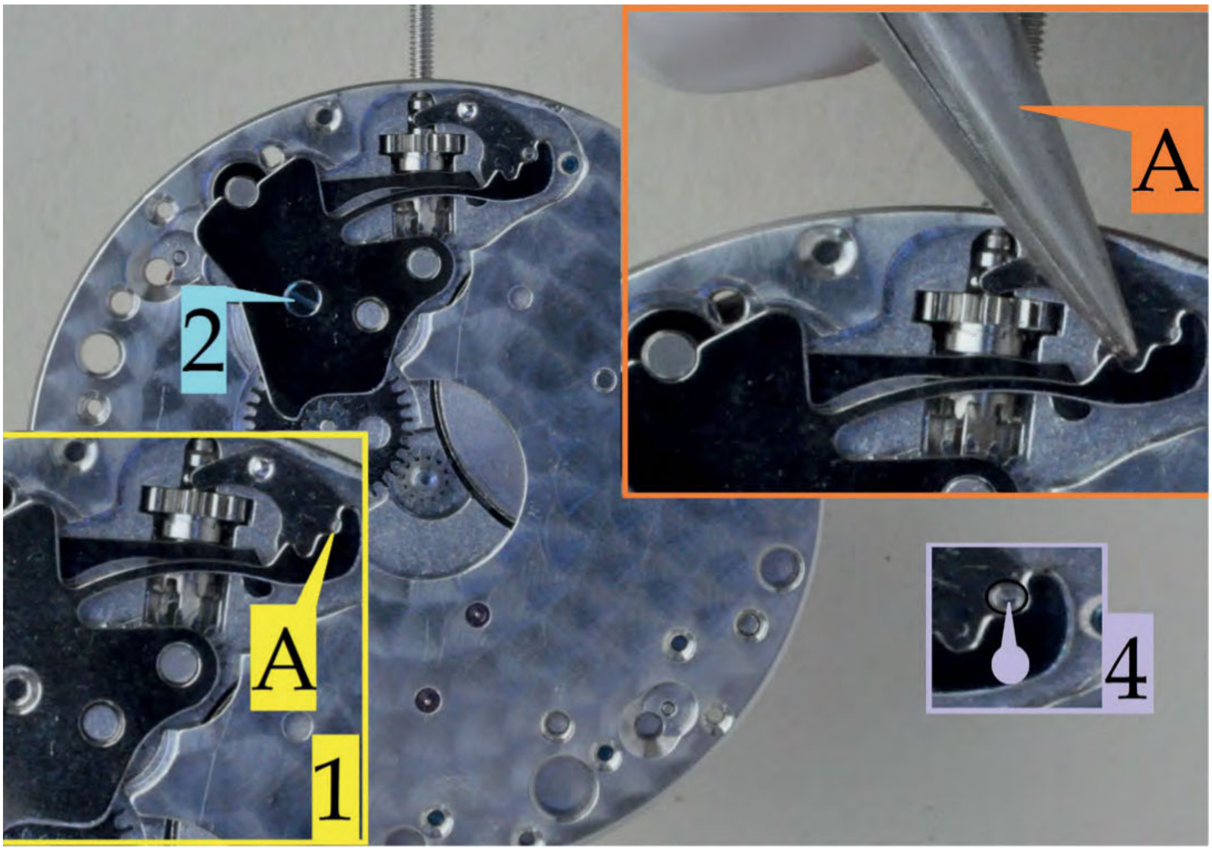


Fig. 186: Replace the cover plate. Refit its screw (2). The bolt springs claw will now be resting on top of the bolt piece nib, as shown in (A1). Pull the spring's claw back using tweezers (A), so that it resides under the bolt piece nib, as shown in (4).

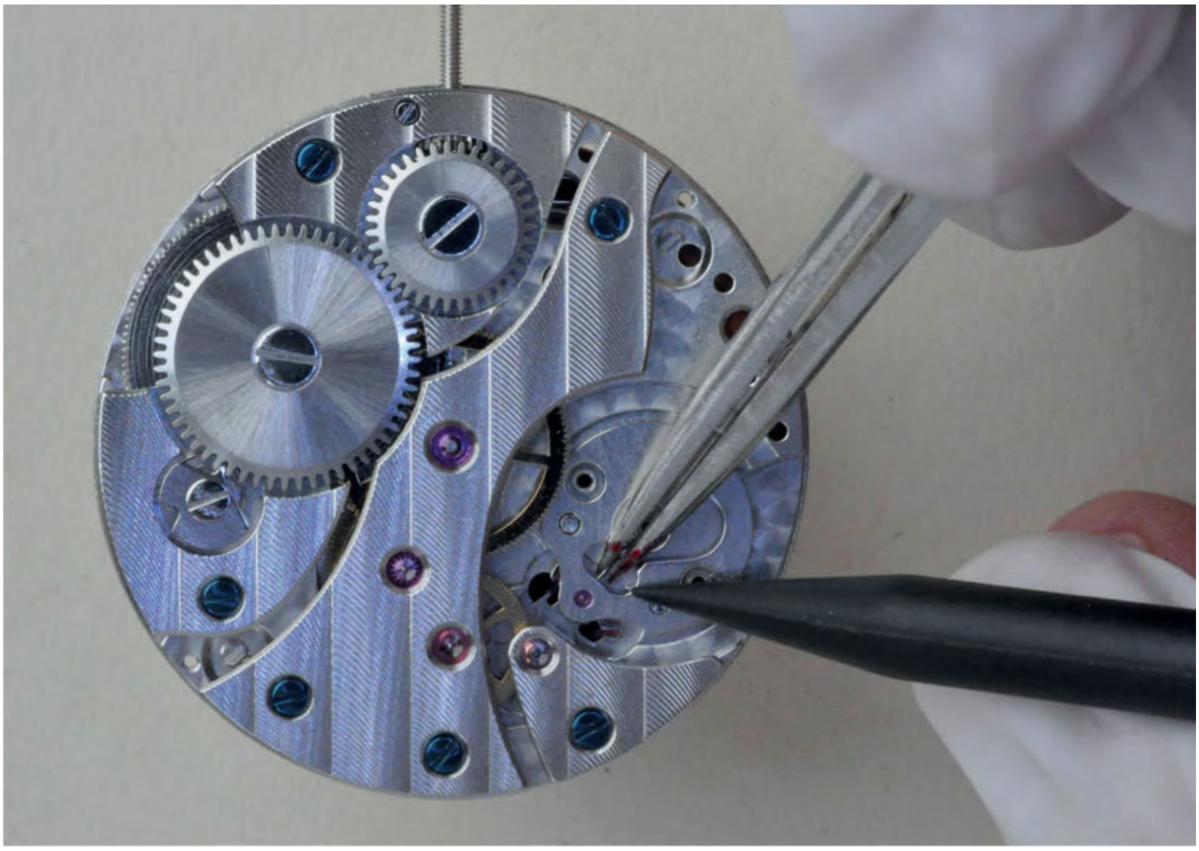


Fig. 187: Refit the pallets and its bridge using a watchmaker's probe to help locate the top pivot in the pallet bridge jewel. Secure the bridge with its screws.

11. Re-fit the pallets in the same fashion as you fitted the train bridge, followed by replacing the balance wheel.

PART III: SERVICING AND CLEANING A WATCH

29. SERVICING A WATCH

Mechanical watches, on average, need servicing every five to eight years. This means that the watch has to be completely stripped down to its basic removable components (which can number sixty or more parts in a basic watch).This is why you take the watch apart in stages: so you can easily identify those components and refit them in the correct place. It is important to make servicing as easy as possible. If you were to clean each and every part separately, it would take you days to clean one watch.

It is also imperative that you fully understand how a watch works as a whole. This means you should be able to jumble up all the parts, and then easily sort them out into their respective groups: keyless work, motion work, gear train, escapement and winding gears.

Tip: if you don't have access to a mentor, I highly recommend taking detailed photos of the watch at each stage as you strip it down. This will give you something to fall back on if you get stuck. This is not something that you should rely on in the future, however. As you progress through the book and practise more yourself, you should find yourself needing to look at the pictures less and less. This is how you will know you are making progress.

PRE-SERVICE CHECKS

The most common reasons for a mechanical watch to stop are:

- Damp air/moisture saturating the movement, causing rust or washing off the oil
- A screw coming loose and jamming itself in the gear train
- The watch being dropped, causing damage to one of the components
- A broken spring

This is why a good watch repairer must be a detective, as every watch is a crime scene (I call this HCSI – Horological Crime Scene Investigation). You must inspect the scene and identify the perpetrator, before cleaning up the mess speedily and efficiently.

This may seem a laborious task, and it will obviously take longer to service a watch. However, I can assure you that, in the long run, it will save you time and a small amount of hair pulling, as you will certainly have fewer return jobs to fix. You should always find the fault first, because if you've just cleaned a watch prior to making repairs, the parts will soon become contaminated with small hairs, dirt or dust from the air in your workshop, or you may smear your freshly applied oil.

Question the Watch Owner

Your first port of call should be the owner of the watch: question them as to the nature of the problem and ask when things started going wrong. They may make your ears bleed as they retell the watch's life story and their family history. There is always some small nugget of information, along the lines of 'It ended up on the floor' or 'I went swimming', which will immediately ring alarm bells. This will help you quickly identify the cause of the problems and save you time checking every single part.

If the watch is a new purchase without any history, you will have to carry out a thorough investigation to try and identify the problems. I normally find that one in four watches is hiding some form of problem, so if you're thinking, 'I'll just clean it and job done', then you're going to be very busy in the future fixing return jobs!

The classic line I hear from students is 'I can't understand it… it was working perfectly after I cleaned it!'What in fact happens is that the nice clean watch works better than normal due to being clean and freshly oiled, thus overcoming any fault – until, of course, the oil's properties change very slightly after being worked and the watch starts to run more normally, when the fault again arises.

Inspect the Outside of the Watch

Inspect the watch before you remove the movement from its case. See if the watch winds and the hands set correctly; if they do not, this may be something as simple as a bent winding crown or the dreaded rust. Next look at the face, as any water damage will be evident. Normally this is seen on the glass – look out for opaqueness (cloudiness), or the hands' decorative plating may have become pickled or discoloured. The luminous paint may also be affected. The dial may have clearly discoloured, or paint could be peeling away and jamming the hands. More obviously, a hand may have come loose, or one or more of the dial's markers may have broken free.

Caution before Opening the Case

If you are handling a watch belonging to a customer or a friend, it is always a good idea to check that the back of the watch hasn't been scratched previously. If it has, point out these scratches, as people are very quick to lay blame, even best friends! Owners tend to have rose-tinted memories of their watch before they hand it to you. It may be advisable to take pictures of the case before you begin the stripdown, as these are often time indexed (they may tally with holiday photos with dates and times).

Upon opening the watch, examine the movement and look for any holes in the plate that should contain screws; most commonly one of the case clamp screws will have come loose. If there are loose parts, take care not to lose them when you take out the movement – this is where the advice on using the centre of the bench and an apron is especially helpful.

Care of the Dial

Remove the hands, making sure to use a dial protector. Remove the dial and place it in a box for safe keeping. Dials are very easily marked and very expensive to repair or replace. They are also the first thing we see on a watch, therefore I would very highly recommend using finger cots when removing the dial.

Condition of the Oil

Refit the stem and place the movement in a movement holder. Have a look at the general condition of the movement, paying attention to the condition of the oil. Has the oil just dried up, or does it look dirty? If it looks dry, try applying some oil to the pivots and see if you can coax the watch back to life.

Be aware that you can't just leave a watch with new oil on top of old: applying new oil is for diagnostic purposes only, and the watch will still need to be serviced if the old oil is dry and/or dirty.

Condition of the Balance Wheel

Look at the condition of the balance's spring. Look for signs that it has been badly adjusted by a previous repairer (or attacked by an over-curious owner): looking from the side it should appear flat and be parallel to the balance rim. Looking down, it should be central to the balance wheel. The balance wheel, when puffed with watch repairer's bellows, should oscillate nicely with no wobbles. The rim of the balance should also be true, flat and round. Carefully and *lightly* grab the balance wheel by one of its crossings (arms) and wiggle it up and down to see the end shake of the balance wheel: this should not exceed 0.05mm. (This may seem an extraordinarily small measurement, and it is: using a micrometer makes it possible to see how small this measurement is – this is discussed later in the book.)

End shake, as you should remember, is the play the balance has between its end stones. If you have excessive play, the balance staff may have to be replaced as this will affect the time keeping. Alternatively, if the watch has shock-resistant bearings on the balance, there is a chance that the bottom setting may have popped out due to a being dropped. You may want to look at this first before you rush out and replace the balance or its staff.

Escapement and Safety Action

This is probably one of the most overlooked areas of a watch by many of my fellow watch repairers. To check the clearances you will need a very strong eye glass (x12 or stronger) – ideally, a x40 microscope is the best option.

Impulse Pin Shake

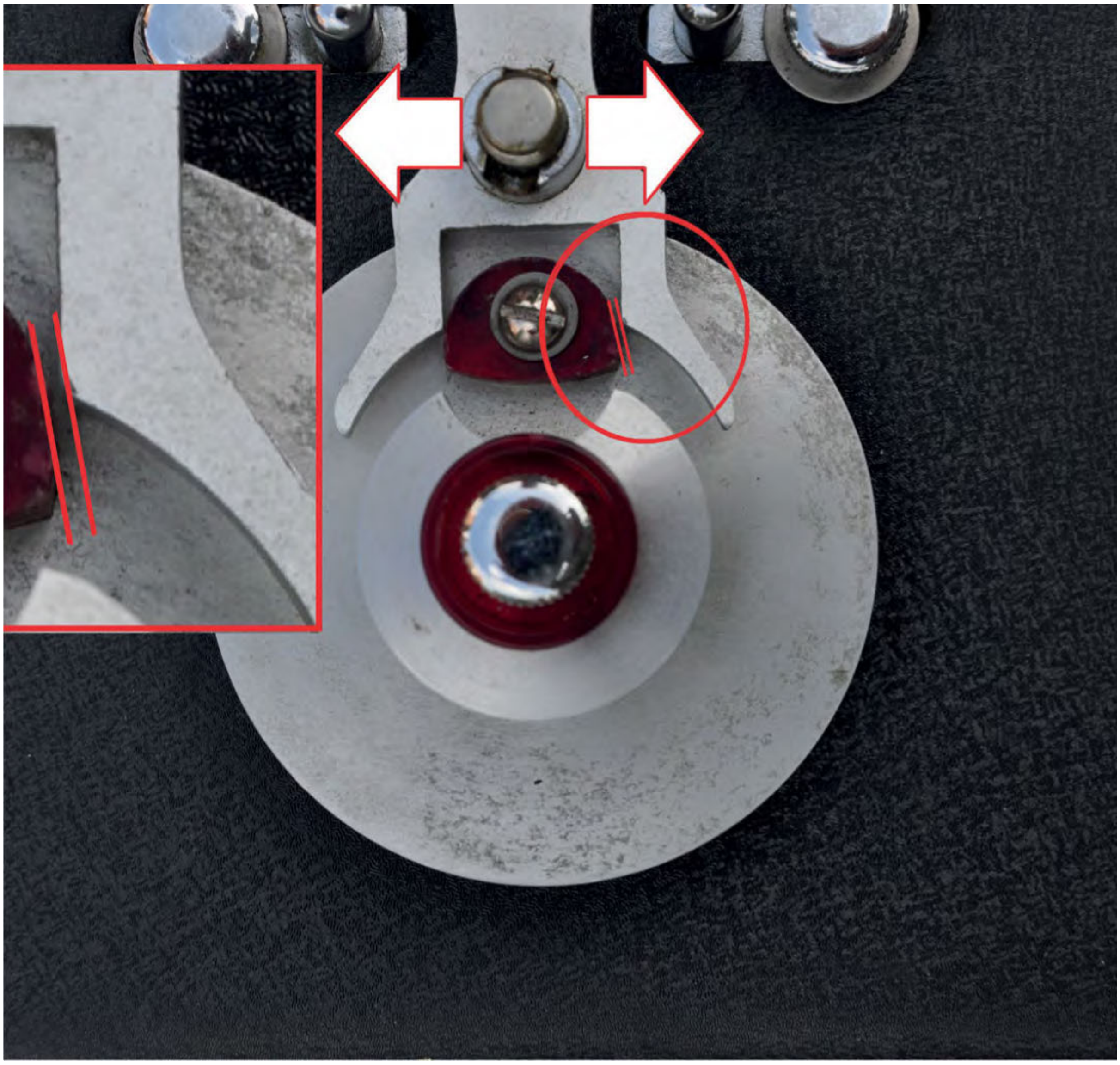
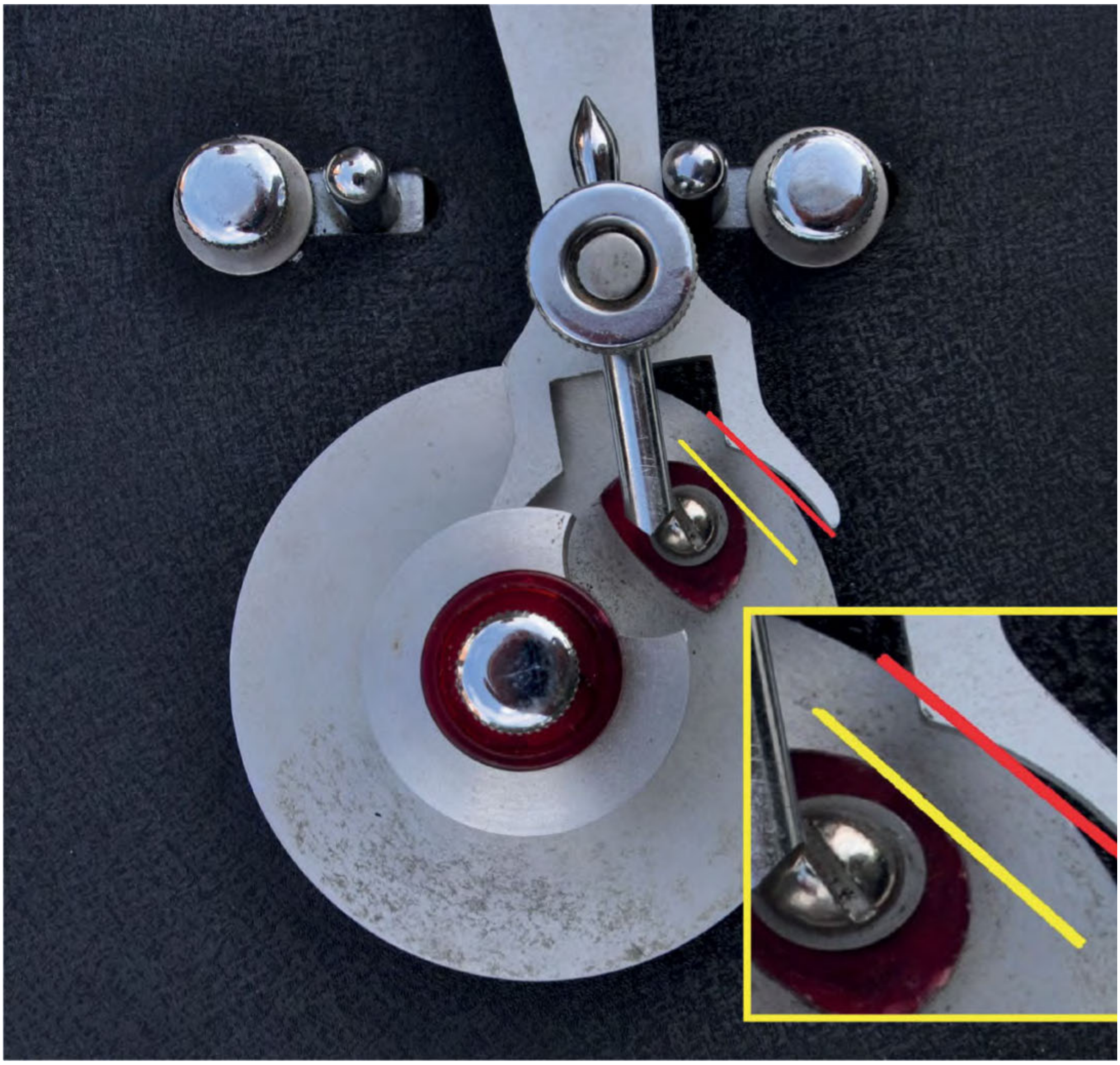


Fig. 188: Impulse pin shake (the guard pin has been removed for clarity), showing the clearance between the impulse pin when in the pallet notch.

Impulse pin shake is the amount of play of the impulse pin when it is in the notch of the pallet fork. To test this, bring the watch's balance wheel to the rest position and hold it still, with your finger applying only light pressure. Take a pair of tweezers, then take the arm of the lever and give it a gentle wiggle. Feel the play between the impulse pin and the pallet fork's notch – you will be unable to see this as the clearance is normally set at 0.01mm; any more than this would mean the pallets are worn. Alternatively, if there is no play between the two this would indicate that the pallet folk is bent. Either way, this means that the pallets need replacing.



Horn and Impulse Pin Clearance

Fig. 189: Horn shake: normal running with the pallet lever resting against the banking pin.

This is when the impulse pin passes the horns of the pallets and is the clearance between them. To check this you must rotate the balance wheel until it is positioned so that the impulse pin is aligned with either the left or right pallet horn. Hold it in that position. Next, with a pair of tweezers lightly grasp the arm of the pallet lever and give the pallets a wiggle left or right to feel the clearance. The amount of clearance isn't vital, as long the amount is equal on both the left and right horn. You may not see this movement, but you should feel it: if there is a noticeable difference between the two horns, check the banking pin on the offending side, as it may be bent. If this is not the case, it may be that the pallet horn itself is bent.

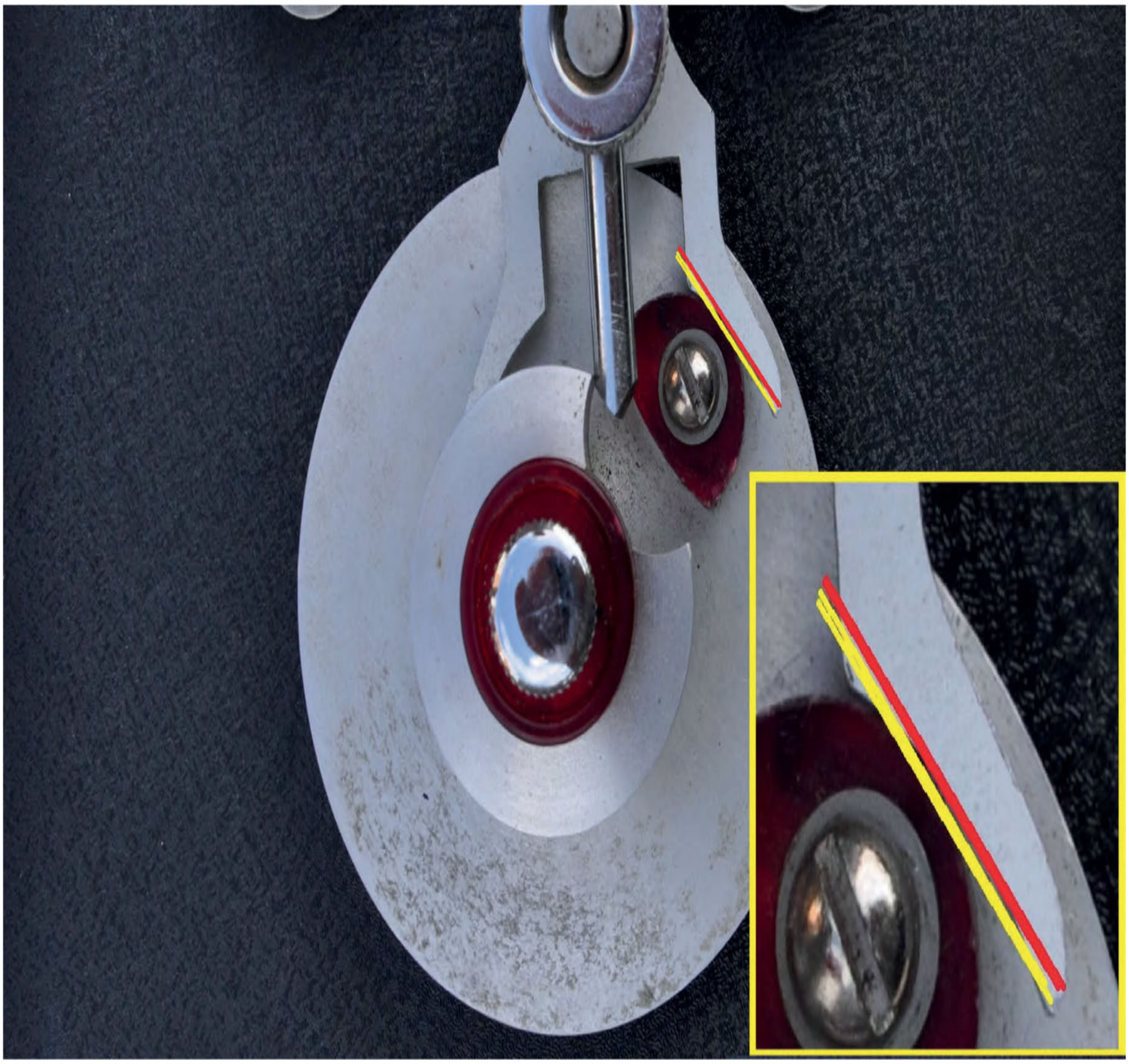


Fig. 190: Horn shake, showing the clearance between the impulse pin and the horns of the pallet lever.

Play between the Guard Pin and Roller

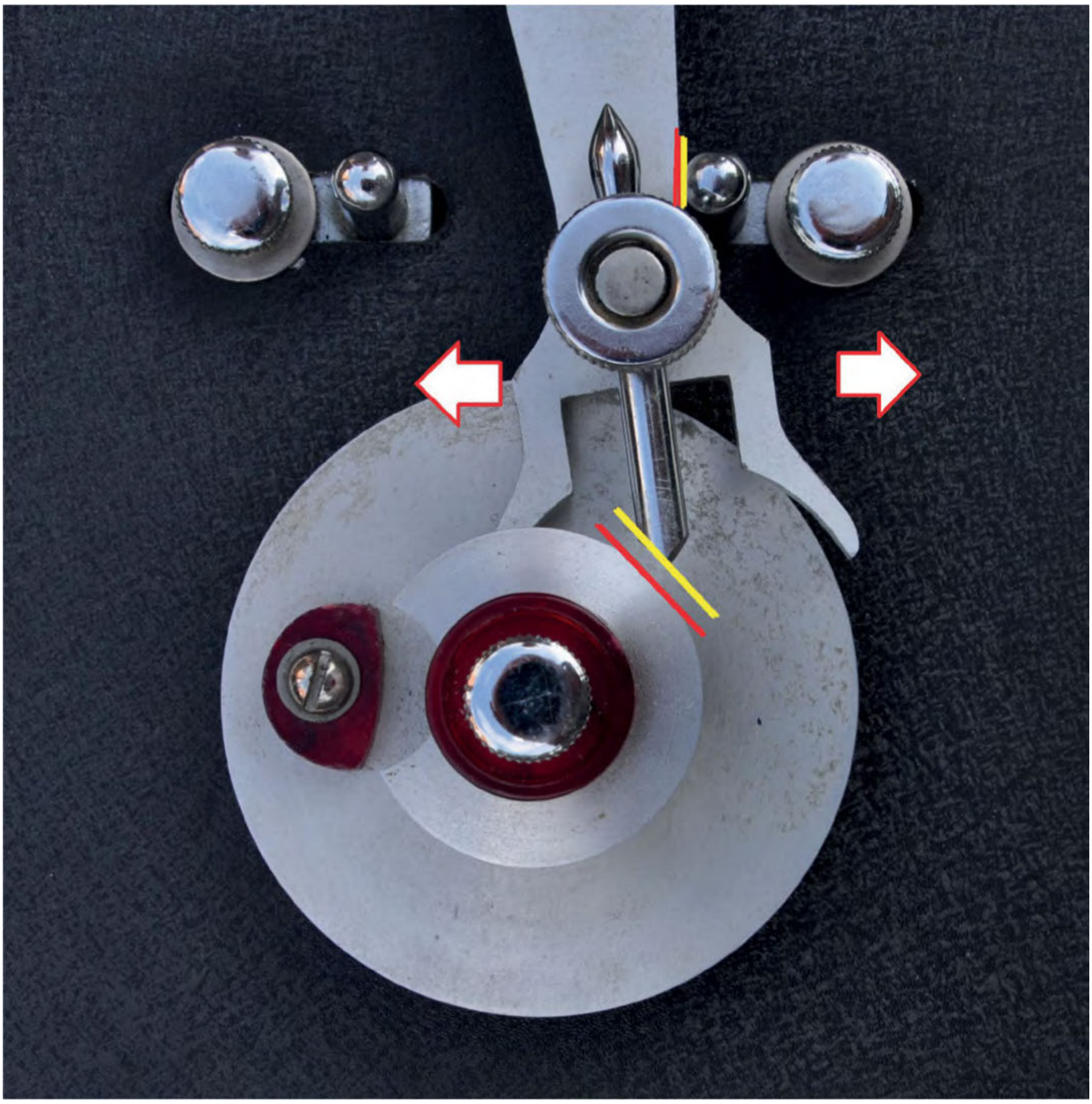


Fig. 191: Guard pin shake; the clearance between the impulse pin and the safety roller.

This is commonly called 'guard pin shake' and is the distance between the guard pin and the safety roller, when the balance wheel is approximately 53 degrees left or right of its rest position. To check this, you will have to rotate the balance wheel approximately a quarter of a turn left or right, depending on which side you are checking. Hold it stationary. Use the tip of your tweezers to wiggle the pallets left and right to see or feel the clearance. This should be equal on both sides.

If it is not, this could be caused by the banking pins being bent, the pallet lever being bent, or more commonly, the guard pin being bent. The most straightforward of these to adjust is the guard pin: you simply straighten the guard pin with a pair of tweezers. The easiest method is to use a microscope, and this is best done when the pallets are in the watch, as everything is at right angles to each other. If you do this by eye, an optical illusion may cause an error in straightening.

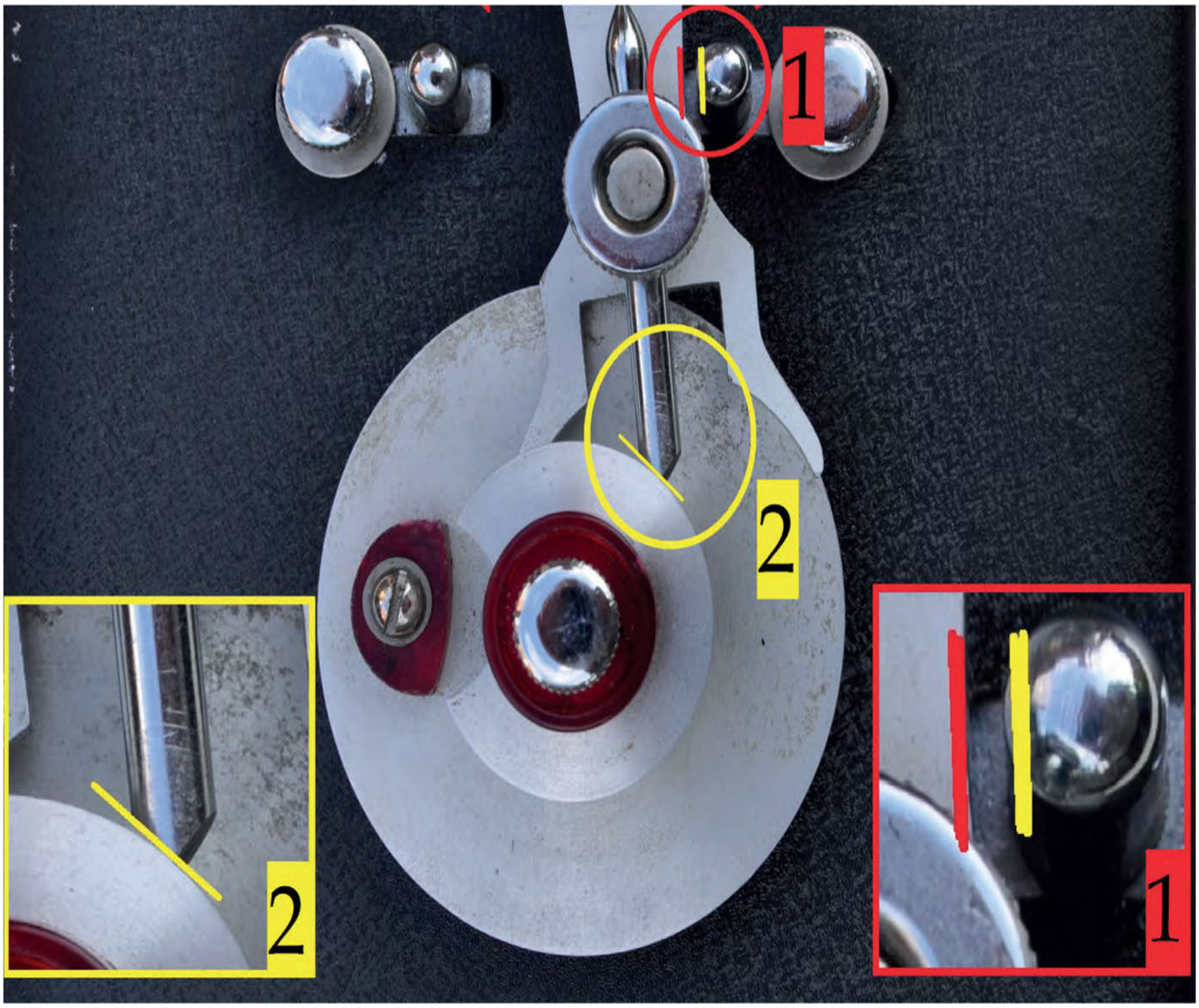


Fig. 192: Images 1 and 2 show the amount of clearance you should be looking for when moving the pallets.

End or Side Shake of the Gear Train

As you remove the bridges and cocks from the watch you must first check the end float or end shake of the balance/pallets/gear train and barrel. To clarify this, you are looking at the up-and-down movement of the arbor in the plates.

To check this, lightly grasp the arbor with a fine pair of tweezers and wiggle it. This movement of the balance wheel, pallets and escape wheel is normally around 0.06mm. If they are either slightly more or less, but are roughly equal, this should be fine. As a guide, the third and fourth wheel tend to have a movement of between 0.08mm and 0.10mm. The centre wheel and barrel have a movement between 0.08mm and 0.12mm.

You should also check the side play of each jewel and bearing grasping the arbor, as this will show you if there is any wear present in the jewel or pivot. This should be no more than 0.01mm. Again, you can feel this movement rather than measure it.

If any of the wheels or pallets have excessive or no end shake this can only be adjusted with the use of a watchmaker's jewelling tool. If the balance has excessive end shake, this can only be rectified by replacing the balance's staff, or by replacement of the complete balance.

As a separate check, if you have any suspicions about any of the wheels, then you should fit the suspect wheel back into the plates on its own and give it a blow with watchmaker's bellows. Check to see if it rotates freely. If it doesn't, this may be due to a bent pivot or too small an end shake.

Condition of the Teeth and Pivots

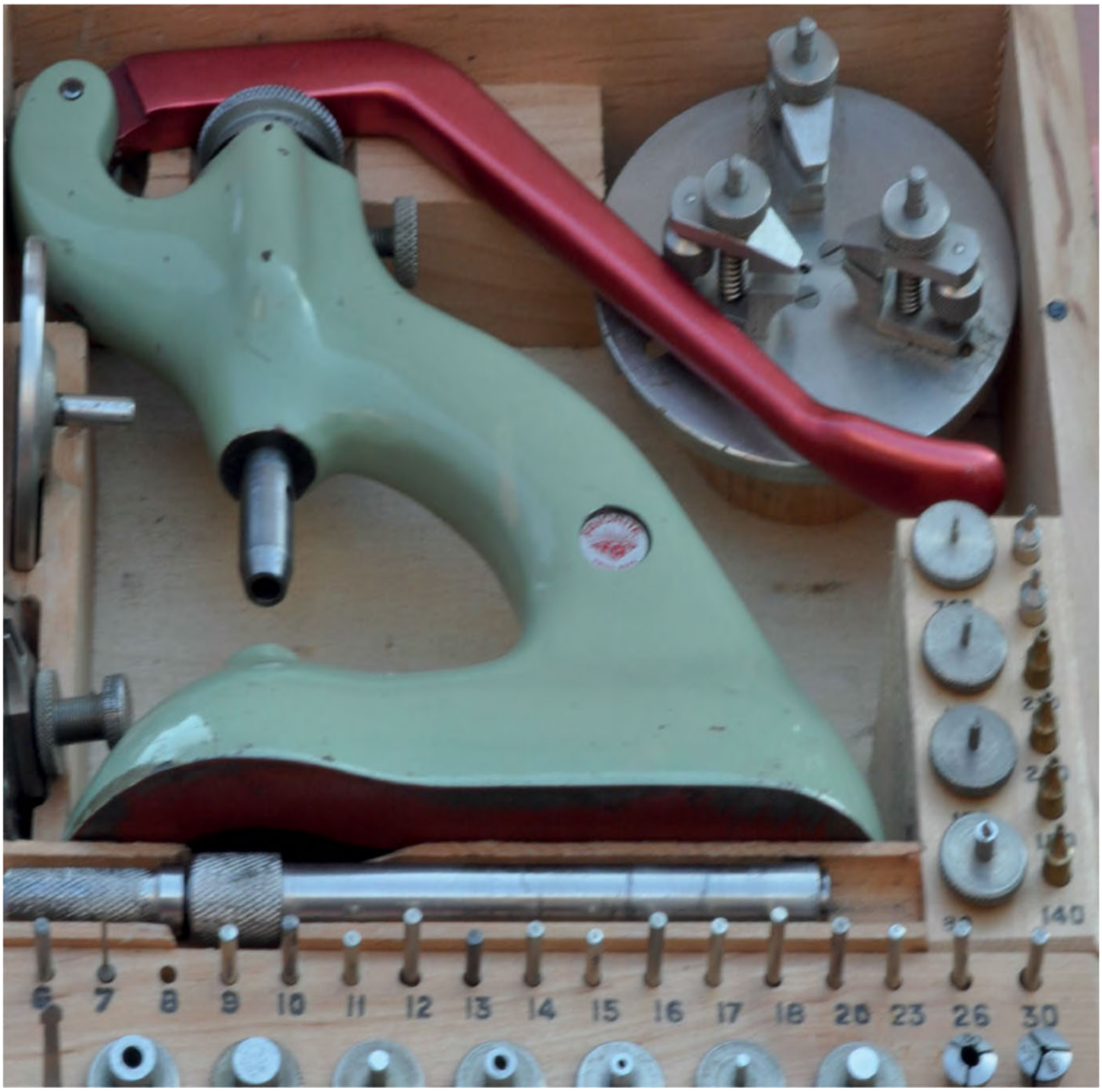


Fig. 193: Watchmaker's jewelling tool, used to adjust the height of the jewels in a plate or bridge, in order to adjust the amount of end shake a wheel has in the watch.

As each wheel is removed, look at each of its pivots. This must be the same for all the wheels/pallets/barrels and balance wheel. All the pivots should be parallel, have a high lustre, and be free from blemishes or score marks. If they are not, that part will have to be replaced. They can also be refurbished by reducing the diameter of the pivot. This removes all the marks. The surface is repolished using a tool known as a Jacot tool. As this action will have made the pivot's diameter smaller, the jewel the pivot rotates in would also need to be replaced with one that is smaller. This also requires the jewelling tool.

When examining the teeth of the wheels, you are looking for ones that may be broken or bent. When examining the pinions you only need to look for rust. If there is light rust on the surface, this can sometimes be cleaned off with a watch repairer's glassfibre pen, by just brushing it over the teeth. This is a good time to look for hairs that may be wrapped around the teeth, as this may be why the watch stopped.

Tip: Care must be taken with the glassfibre pen because if bristles break off they can stick in your skin, and these can be as irritating as a bramble thorn stuck in your finger. It is therefore best to do this on a scrap of paper and dispose of it soon afterwards.

The Jacot tool and the jewelling tool are very expensive tools (approximately the price of a television), and are not necessarily something a beginner should own. If you are lucky enough to have a mentor, they may have one they are willing to let you borrow.

Condition of the Mainspring

Once the mainspring has been removed from the barrel you must have a good look at it, as the surface must be free from blemishes or creases, and its spiral should be a graceful curve. At this stage you can pinch the spring between your fingers and run your fingertips over the surface, when any imperfections can be felt. Modern white metal springs will have a reverse curve, where the end of the spring turns in the opposite direction, while older, blued springs have the more expected shape of a gradual spiral.

When looking at an older blued spring you must decide whether it has just become tired, because when these older springs reach the end of their life the distance of the coils becomes closer. If two thirds of the coils are less than 3 or 4mm apart, then the spring needs to be replaced, preferably with another blued spring. If you are not able to source a suitable blued spring, then fit the next nearest modern equivalent (replacing mainsprings is discussed elsewhere in this book).

30. CLEANING A WATCH

The majority of modern watches in water-resistant cases will only require the movement's parts to be degreased. This means washing off the old oil so that fresh oil can be applied. Many 'old school' watchmakers used benzene or pure Naphtha. In the modern age, both of these have been found to be bad for your health if inhaled. You will quite often see watch repairers using lighter fuel as a modern replacement, as this still contains Naphtha. However, many watchmakers are blissfully unaware that modern lighter fuel is contaminated with a small amount of oil, making lighter fuel a very poor degreaser. Very small particles of oil will be left on any part that you try and clean when using this substance. If you apply oil to the surface of anything that has been washed in lighter fuel, the oil will have spread by the next day. The only thing that lighter fuel is good for is cleaning mainsprings, and even then only when the fuel is applied to a lint-free cloth and used to wipe the spring clean.

Don't be fooled into thinking that washing watch parts in degreaser is a quicker way of cleaning a watch. You would most certainly be wrong in this assumption. You would have to handle every single part and brush it whilst in the degreaser. This certainly increases the chances of you losing something. However, if you are pressed for space and have no room for a watch-cleaning machine or ultrasonic tank, this is generally the only way for you to clean a watch.

Warning: When using degreasers you must use them in a well-ventilated area, and keep them away from plastics such as your plastic sink or your storage containers as some brands of degreaser may melt or discolour them. Most degreasers are highly flammable, so I would recommend keeping them out of direct sunlight.

To get started, you will first need a small jamjar, like the ones you get in hotels, or a very small Kilner jar. Fill this with some horological degreaser (such as Elma Spirol or Essence of Renata) and drop any parts into the jar to be cleaned. Using an artist's camel-hair painting brush or similar, loosen off any contaminate on the movement part being washed, paying extra attention to the teeth on the pinions/wheels. After soaking in watch degreaser for a few minutes, blot the parts on tissue paper and dry off with a few puffs of a watch repairer's puffer or bellows.

Tip: Remember to be extra careful with the degreaser on your bench, as it can affect any plastic material it comes into contact with.

It is a good idea to give the jewel holes a final clean by using sharpened peg wood. You can use a watchmaker's knife or a Stanley knife to sharpen the end of the peg wood to a gradual taper, not unlike a spear. This will be used to clean the oil sink in the jewel hole. This is best done when the end is soaked in some degreaser and then used to clean a jewel hole. Try not to overwork the peg wood in a given jewel hole (about a half turn normally suffices), as it has a tendency to break off in the hole. Don't be tempted to use one of the wheel's pivots to push out the broken shard of peg wood, as the pivot will most definitely break off as well. The best thing to use is an old oiler filed down to a fine taper, and push out the shard with it. Special care must be taken here, as pushing out the broken peg wood can result in cracking or breaking the jewel, or possibly even pushing it out.

CLEANING THE BALANCE WHEEL AND SPRING

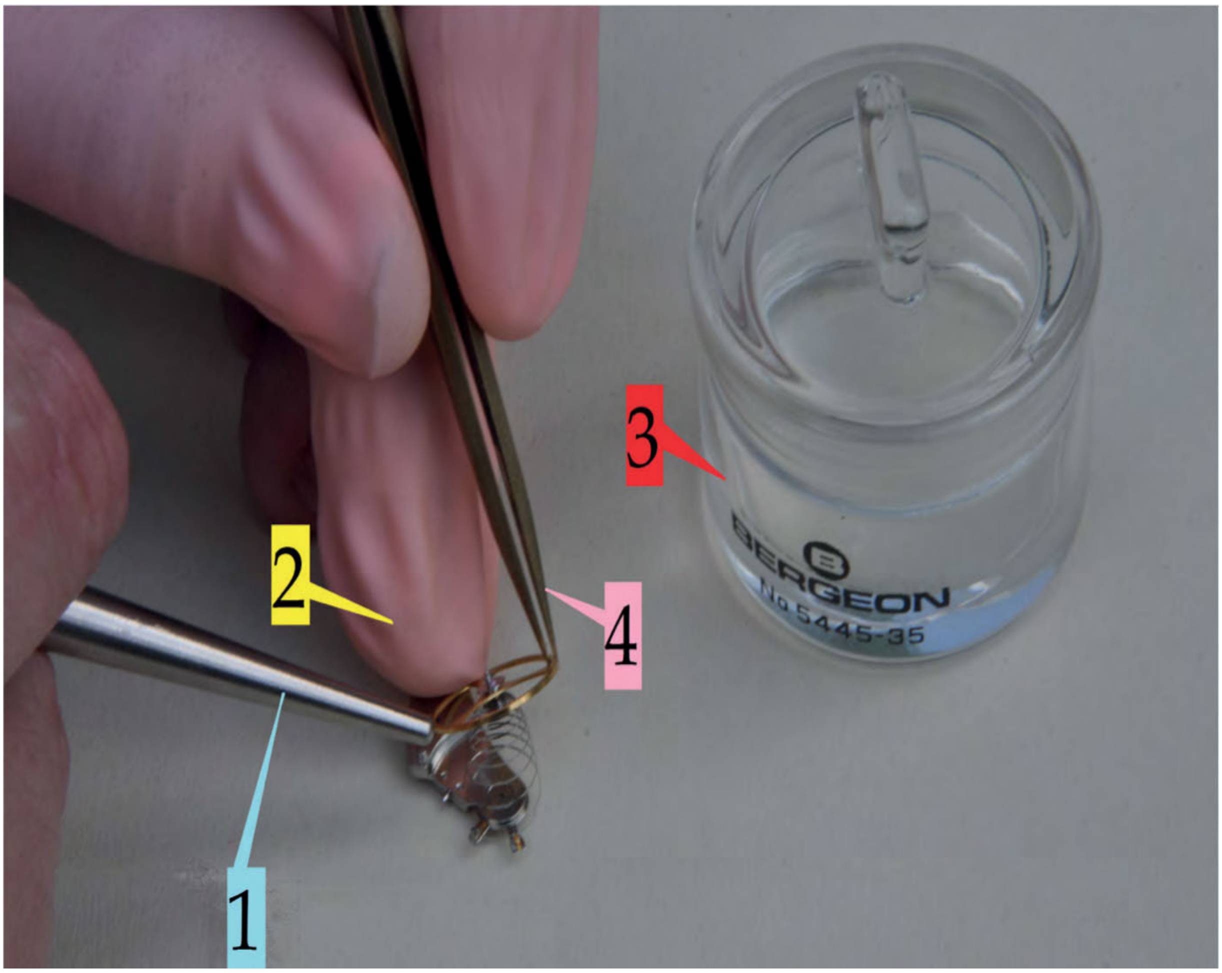


Fig. 194: Drying a balance assembly after cleaning: (1) Watchmaker’s bellows. (2) Position of your index finger. (3) Essence jar, commonly used by watch repairers. (4) Tweezers holding the balance rim.

With the balance and cock lying on its back, pick it up by the hole in the cock and pop the whole assembly in a pot or essence jar filled watch repairer’s degreaser. After a minute lift the balance assembly out of the degreaser. Again, pick it up by the hole in the balance cock and place it on the bench.

Place your left middle finger on the fat end of the balance cock. With thetweezers in your left hand (as seen in Fig. 194), lift up the balance wheel, pulling it away from the balance cock

Warning! Do not pull the cock higher than 1cm. If you do, you risk stretching the balance spring, making it unusable.

Using watch repairer’s puffer or bellows in your free hand, lightly puff a stream of air into the coils of the spring to dry it off.

Warning! Do not be too vigorous with the puffer as there is a high chance of the coils of the spring becoming tangled.

Tip: Once the balance is fitted in the watch, you may find that the coils of the balance spring stick to each other, causing the watch to gain time. If this is the case you will have to clean the balance assembly again. This can sometimes be caused by dirty degreaser or oil on the balance spring. If you find that the coils continue to stick together, there is achance that this may be caused by magnetism. If you have a compass, wave the balance or watch over it. If the pointer or hand moves, the watch has become magnetized. To rectify this, you will need a watch repairer’s demagnetizer.

LIGHT/MEDIUM CLEANING

For a light to medium clean you will need some type of horological cleaning fluid. There are three main types: ready to use, concentrated, or ecological. The ecological fluids are less pungent than the other two, making them ideal to use in the household. They also tend to be much kinder to the metal you are cleaning. The only down side is that they take forever to clean anything. If you are short of time, the ready-to-use or concentrated type are currently far superior.

A general rule of thumb is that the stronger it stinks, the better it cleans, so you will need to use these fluids in a well ventilated area. You will also need a compatible rinse to accompany the cleaning fluid. Remember to check when purchasing the cleaner and rinse that they are compatible. At the time of writing, examples of companies who make both cleaning and rinsing fluids include Walker, Elma, L&R and HP Storey.

Take three small jars, one filled with cleaner and the other two filled with rinse. Two rinses are used because as you move the parts from the cleaner to the rinse some of the cleaner will contaminate the rinse. This means that a small residue of cleaner will be left on the surface of the cleaned parts. By using a second rinse, the parts will be free of any contaminate, helping to prevent the oil from spreading. You could, if you liked, add a fourth jar. This one would contain degreaser as a final rinse. Once you remove the parts from the final rinse, use the blotting method to dry the parts, and use a watchmaker’s puffer or bellow to dry off the excess.

ULTRASONIC CLEANING

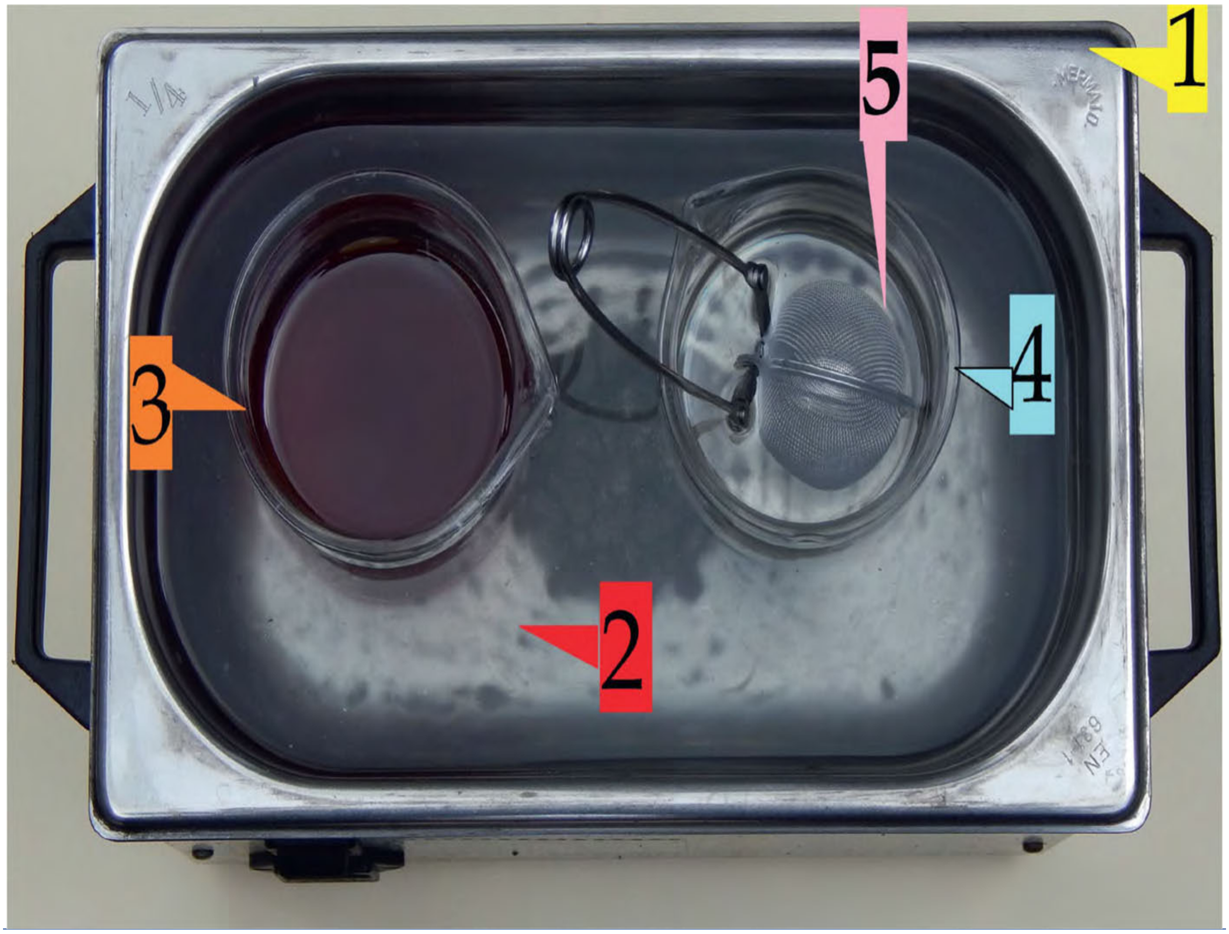


Fig. 195: A typical jeweller's ultrasonic unit (1), filled with water (2). (3) A jar filled with watch-cleaning fluid. (4) A jar filled with watch-cleaning rinse (in the jar is a tea strainer, used to hold any small parts during cleaning).

Normally ultrasonic cleaning involves a stainless-steel tank filled with a fluid. The tank passes ultrasonic waves through the fluid and these waves loosen any dirt particles from the object you are cleaning. They sometimes have heating units to warm up the fluid. Professional watchmakers use these machines with just soapy water (water and washing-up liquid) to clean watch cases. This ensures the cleaned movement isn't contaminated by detritus from the watch case when the movement is refitted, as watch cases and bracelets are dirt traps.

You can use these units to clean watch movement parts but the problem with an ultrasonic is that you would have to keep changing the fluid. Another problem is that the mesh of the basket that the machine normally comes with is too large, and most watch parts will fall though the holes. If you fill an ultrasonic tank with water you can pop your little glass jamjars filled with cleaner or rinse in the water, turn on the machines, and the waves will penetrate through the glass, buzzing the parts inside the jar clean.

This method will also work with the smaller and cheaper battery-powered ultrasonic units; they are not as strong as the professional units but are certainly better than nothing, if you're on a tight budget. The parts can be individually dried with your watch maker's bellows. Alternatively, they can be collectively dried in a box lightly filled with boxwood sawdust or drying granules such as Maizorb. This will soak up the remaining rinse left on the surfaces of the watch.

CHALK BRUSHING

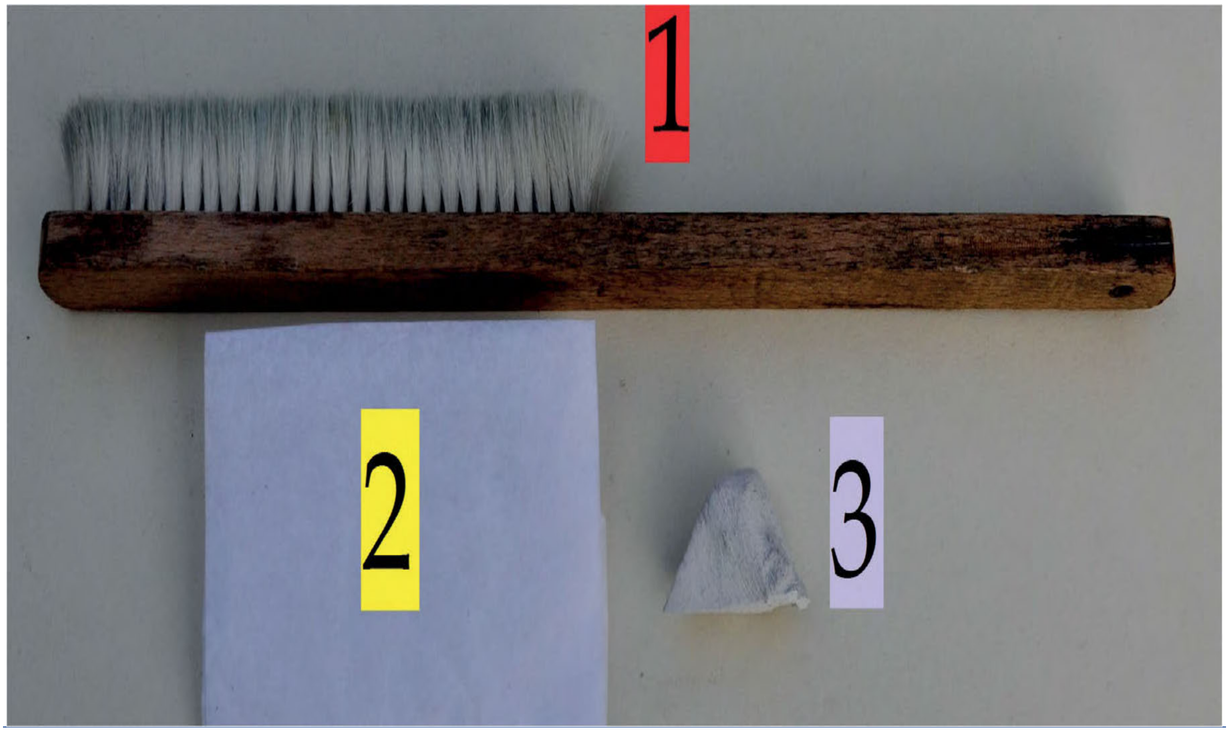


Fig. 196: (1) Four-row chalk brush. (2) Watch repairers' tissue. (3) English chalk (French chalk is very dusty).

Chalk brushing is a cleaning treatment traditionally used for antique watches. It is appropriate to use this method if, after cleaning with chemicals, the watch parts still seem a bit flat and lacklustre. This requires a watchmaker's four-row cleaning brush with soft bristles, newspaper, and a block of French chalk (easily bought from clock material suppliers).

The technique is simple. Hold the part to be cleaned in the newspaper so your fingers are not touching the part being brushed. Charge the brush by rubbing it on the surface of a block of chalk.

Next, brush the part by dragging the chalked brush in a downward motion, starting from the top of the part and exiting on the paper. This has three effects: the chalk acts as a very soft abrasive, buffing the surface of the part. Secondly, the chalk acts as a medium for the dirt, stopping it soiling the brush. Thirdly, the paper acts as a medium for the dirty chalk to transfer to. Don't be tempted to rub the bush up and down as this will stop the dirt being transferred to the paper and will blacken the brush, negating its cleaning effect.

After brushing it is recommended that the parts are re-cleaned in rinse or degreaser. This will make sure there are no chalky deposits left on the parts. If this were the case, the chalk deposits could lead to wear.

Tip: This method of cleaning is very good for giving silver and gold watch cases a light buff.

DEEP PROFESSIONAL CLEANING

Deep cleaning is done using an electric watch-cleaning machine. These have been in service in watch workshops since the 1940s. They consist of three/four jars, similar to coffee/tea storage jars. The first jar is filled half way with cleaner, and the other two/three contain the same amount of rinsing agent. There is an additional sort of metal jar with a heater inside: this is the drying chamber.

A basket holding the dismantled watch is put in each jar, and is rotated in the fluid by an electric motor. The basket will be put in the cleaner first and will stay in there for about six minutes. Most cleaning agents exert some sort of detergent action, so the jars are fitted with metal blades to prevent foaming caused by the cavitation (oscillation movement) of the motor.

The basket will then be taken out of the cleaning fluid and spun for 30sec to get rid of the excess cleaner so as not to contaminate the rinse. The basket is then placed in the rinse and rotated for 3–4min, taken out and again spun for 30sec, then placed in the second rinse, and so on until the basket reaches the last chamber, the drying chamber. Here, the basket will spin in hot air for approximately 3min. After that it will be raised up above the drying chamber and spun for a further 2min until the basket has cooled off.

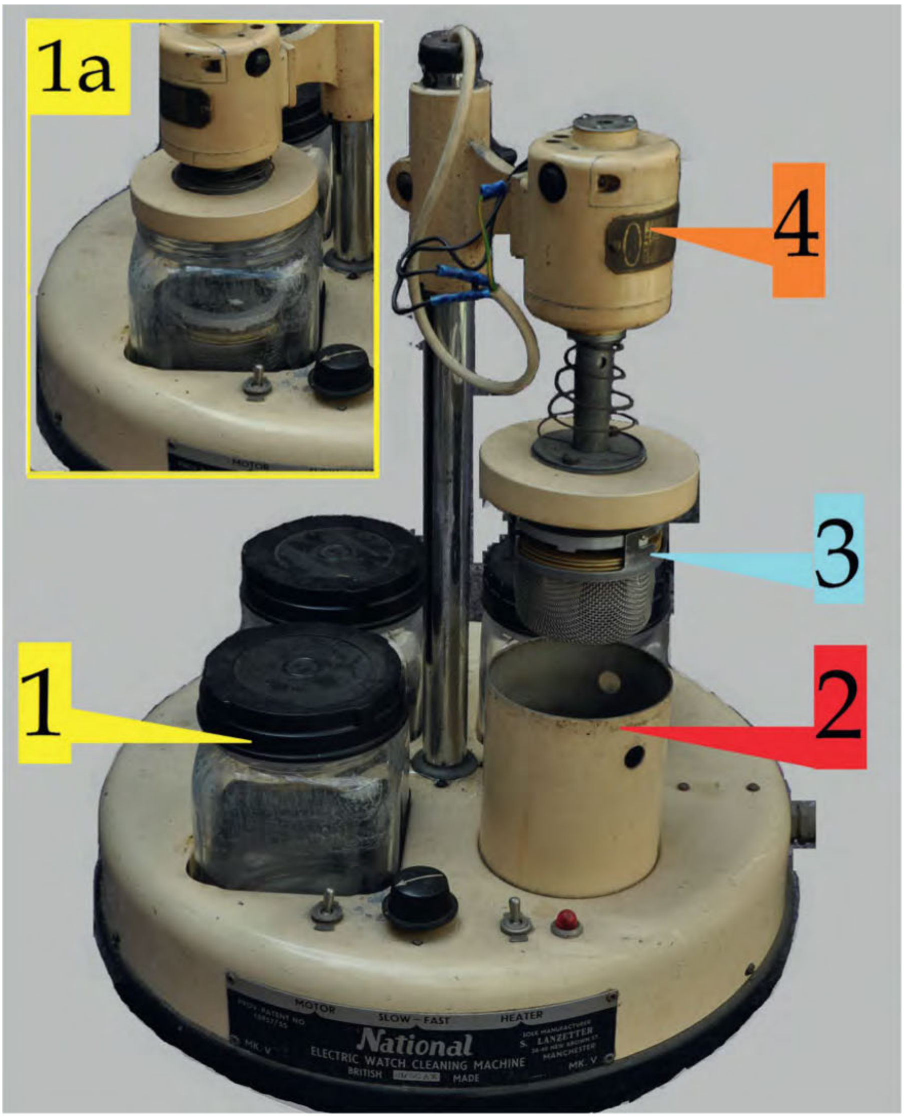


Fig. 197: National watch cleaner from the 1960s. (1) One of three jars filled with cleaner or rinse. (2) Heated drying chamber. (3) The basket that holds the disassembled watch movement. (4) Electric motor. (1a) The basket in the jar during a cleaning cycle.

Tip: The cleaning and rinsing fluids (exactly the same substances as mentioned earlier) are good for a maximum of fifteen washes, or until they start to looks like the colour of spiced rum. They must then be replaced, as they will have become heavily contaminated with oil, which will coat the surface of the plates and jewels as the basket leaves the final rinse; after a week or so the oil will spread. It is advisable to keep these fluids out of direct sunlight, as most of them are very combustible.

With the older/cheaper watch-cleaning machines, the basket is moved on from one jar to the next by hand. This means that these machines have to be nursed. The more expensive machines are fully automated, meaning you have spare time when one watch is being cleaned, so a second could be prepared ready for cleaning, or you have time for a cup of coffee. It’s also worth mentioning that some models of automatic machines have a built-in ultrasonic unit which passes ultrasonic waves though the fluid so that a dual cleaning action takes place.

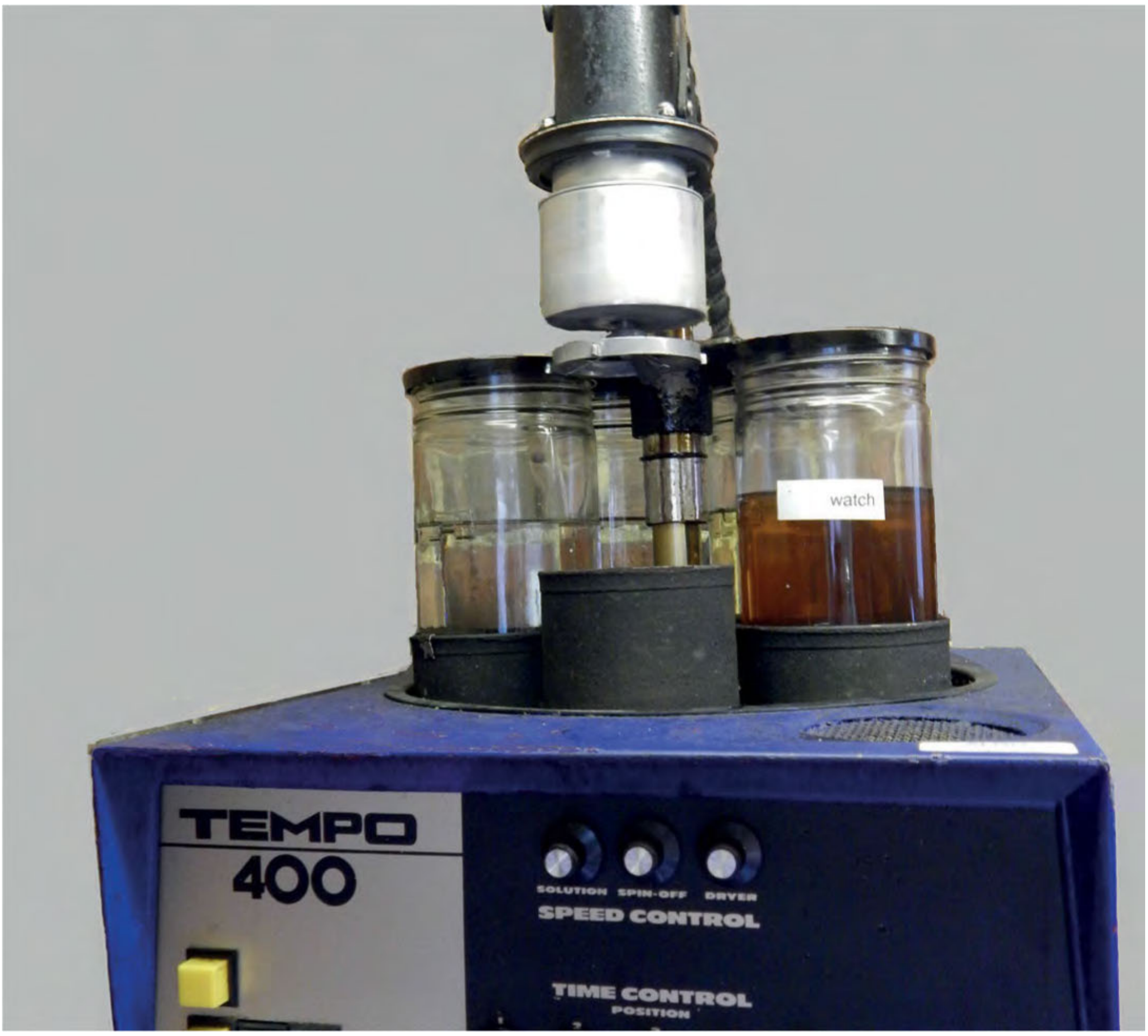


Fig. 198: L&R Tempo 400 fully automated watch-cleaning machine with three rinse jars, one cleaner jar, optional ultra-sonic and heater unit.

Tip: Please remember that these machines are also using noxious chemicals, so always use in well ventilated areas.

DISPOSING OF CLEANING FLUIDS

Some cleaning fluids need to be disposed of at your local household recycling centre; others can simply be poured down the sink. It is very important, therefore, that you read the instructions on the label of each fluid you use, so you dispose of it in the correct way. If you are in any way unsure, contact the manufacturer, who will undoubtedly have a ‘Health and Safety’ sheet regarding the active components of each fluid.

31. OILING

It was mentioned earlier that watch oil only lasts, on average, five to eight years. This average time is how long modern synthetic oils last before they start to decay or dry out. However, you wouldn't leave five-or eight-year-old oil in your car, would you? In the bygone age of watch repairing, animal oils were commonly used, such as whale oil; these have a superior lifespan, and were less likely to 'creep' or dry out as compared to their modern counterparts. This is due in part to the fact that such oils contain fatty acids, which help them adhere to the surface they are lubricating; furthermore the composition of whale oil means that it acts like a wax as well as an oil, which helps it to stay in one place. That said, I for one, feel it's rather unfair on the poor whales! So we have to make do with what we have, and rightly so.

In watch repairing we use minuscule amounts of oil, unlike cars that run in a bath of oil. Watches only need very small amounts of oil in very specific/precise locations. Most watch gears either rotate very slowly, with high torque, or have very little torque and rotate very fast, with little energy to keep them in motion. This means you need to apply different types of oil to different parts of the watch, depending on these factors. The quantity of oil used in a watch is minute, but this small amount is distributed to every pivot on both sides of the watch. Grease is applied to the mainspring and the sliding parts of the keyless work.

There are many different types of oil on the market, and simply choosing which lubrication to use can become very confusing, not to mention which is best. Some people use just one type of oil, but in my opinion this is very bad practice, and is best left with watch repairers of the nineteenth century. You can just about get away with three oils and perhaps one or two greases – though when buying your oils, you will need no more than 2ml of any type, and this will last years, even for a professional.

I will assess the oils you will need for the type of person you think you are, out of three basic groups:

Hobbyist: The collector, dealer or tinkerer.
Amateur: The person who fixes watches for fun for friends, family and for a little cash.
Aspiring professional: The person wishing to take up watch repairing as a career.

The oils needed by each category are as follows:

Hobbyist:
Light oil (escape wheel/third wheel/fourth wheel/balance pivots): Moebius 9010
Heavy oil (centre wheel/barrel arbor/barrel/motion work): Moebius HP 1300, or Moebius D5
Pallet oil: Moebius 941/2
Keyless work: Moebius 8301 grease, or D5 if on a tight budget
Mainspring: Moebius 8200 grease

With this selection of oils the most basic of watch repairs can be achieved.

Amateur:
Light oil (escape wheel/third wheel/fourth wheel/balance pivots): Moebius 9010
Heavy oil (centre wheel/barrel arbor/barrel/motion work): Moebius HP 1300 or Moebius D5
Pallet oil: Moebius 941/2 and Moebius 9415 pallet grease (for fast beating watches over 19,800bph)
Mainspring: Moebius 8200 grease
Keyless work and upper crown wheel: Moebius 8301 grease

Aspiring professional:
Light oil (escape wheel/fourth wheel/balance pivots):
Moebius 9010
Medium oil: Moebius HP 500
Heavy oil (centre wheel/barrel arbor/barrel/motion work): Moebius HP 1300 or Moebius D5
Cannon wheel grease: Moebius 9501
Keyless work and upper crown wheel and chronograph lever grease: Moebius 9504
Treatment of escape wheel/pallets and end stones:
Fixodrop 8941
Pallet oil: Moebius 941/2 and Moebius 9415 pallet grease (for fast beating watches over 19,800bph)
Mainspring grease: Moebius 8200

All the oils and greases mentioned I currently use or have used in the past, but they are certainly not the only oils you can use. If you talk to your fellow watch repairers, they will all have their own choice of oil/grease, and it is not for me to say their way is wrong. All I *can* confidently say is, don’t be nervous of experimenting with new oils/greases, as a favourite oil/grease quite often becomes unfashionable and the quality seems to decline. My advice is always to use whatever the watch manufacturers recommend. If you can, obtain the data sheet from the movement manufacturer, as even they use different oils on the same movement.

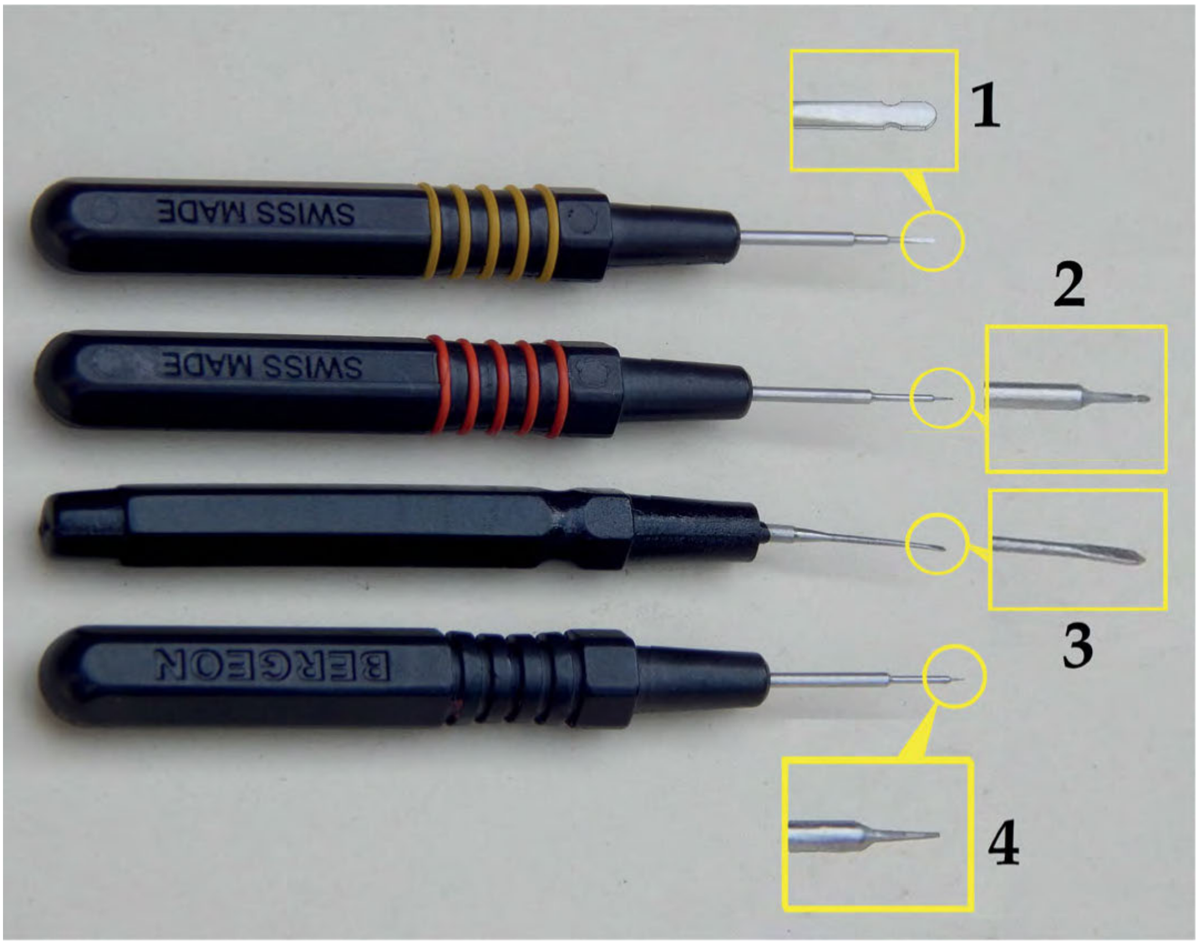


Fig. 199: Watch oilers: (1) Large Bergeon ergonomic oiler. (2) Super-fine red ergonomic oiler. (3) Basic oiler (you can see that the tip is poorly shaped). (4) A broken oiler made into a pricker.

THE TOOLS: OILERS

Oilers are normally sold in sets of four or five. The best budget sets are made by Bergeon and A&F Swiss. At a push, you can make do with just one black oiler called a three-in-one oiler (also made by Bergeon) if you are on a really limited budget. This oiler actually has three blades for the same handle. The oilers I have just mentioned quite often need some sort of adjustment in order for them to work, but if money is no object then I can highly recommend Bergeon's ergonomic oiler set. They are about seven times the price of the other oilers and they're still as fragile as the cheaper oilers, but they are ready to use as soon as you get them home.

If your oiler looks broken when you purchase it, it probably isn't. Pull the metal end out of the plastic and turn it round, as manufacturers insert the needle into the handle backwards to protect it (this is generally true for the cheaper type of oilers). Another thing to note about the cheaper type is they often come with three spare blades per oiler, inside the handle. These often need to be coaxed out with a piece of sharpened peg wood or your tweezers.

To use the oiler, place the needle tip in and out of a pool of oil. This will charge it with a small amount of oil. To apply this oil to a watch's pivot, the oiler must approach the pivot and its oil sink at a near right angle. To transfer the oil you must precisely touch the side of the pivot and the bottom of the oil sink.

Testing your oiler: Before using your nice new oiler it is always a good idea to have a play with it, to see if it performs in the manner it is supposed to. You commonly find the cheaper oiler never works as it should, and you need to make some modification to it to make it work as you expect.

Sharpening your oiler: The ideal shape for the end of an oiler (in my view) is similar to a screwdriver blade with a curved end. The cheaper oilers tend to look as if they have a turnip stuck to their end. My advice is to flatten the sides of the turnip blob, just as you would sharpen your screwdriver blade. Use a diamond or oil stone, but remember to form the tip to a sharp point, as this will help the oil transfer from the oiler to the pivot or end stone. The oiler will become dull in time with use and will require sharpening.

Storing Oil

There are many types of oil pot, some more expensive than others. Ideally you need to have a separate lid for each oil pot, in order to keep the oil free from contaminants. Some oils are used more than others, and this will help keep them fresh for longer. You must bear in mind that watch oils have been highly refined to be as free from impurities as possible: this makes them very expensive, and they are only any good if they are kept clean.

Using and Applying Oil

Never be tempted to use oil straight from the bottle: this is as bad as 'double dipping' crisps in a dip that you are sharing with friends. For this reason, you must dispense a very small amount of oil into an oil cup and use this to apply to the watches you're cleaning. It is actually quite a task to get the oil out of the bottle in the first place. I would suggest using a cotton bud stalk (with the bud removed) to transfer the oil from the bottle to the cup. If you cut the stalk in half, this can be stored in the container that the bottle comes in, thus avoiding any contamination from oil to oil. This oil should normally be changed once a week to keep your oils dust and dirt free. To help preserve the life of your oil, its best to store your bottles in a box in your fridge (or other cool location if your partner objects) until needed for dispensing.

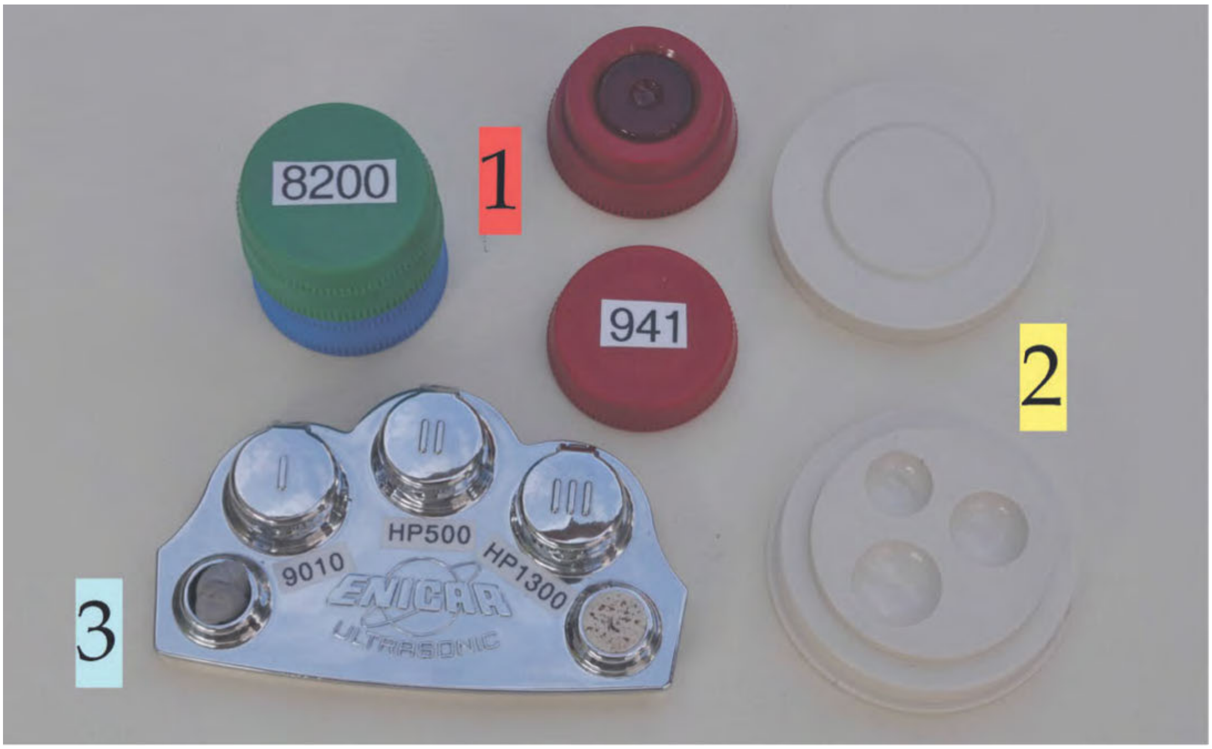


Fig. 200: Oil storage. (1) Individual oil pots. (2) Three-in-one oil pot. (3) Three-pot oil stand with separate lids.

Tip: Best practice would be to use a separate oiler for different grades of oil to prevent cross contamination of one to the other. Alternatively you can clean the oiler's tip by pushing it into some elder pith or king wood before using a different grade of oil. There is also a polystyrene block (foam-absorbing cleaning block Bergeon 7011-BM) that seems to be getting more popular these days. All these can be brought from all material suppliers, or via the internet.

Controlling the amount of oil picked up by the oiler can be done firstly by changing the size of the oiler being used, and secondly by changing the speed with which you take the oil out of the oil pot. Thus if the oiler tip is dipped into and out of the pot quickly it will take up a large amount of oil, but dipped slowly it will take up just a small amount of oil.

If you require a tiny amount of oil, for example when applying oil to the pallet stones, you can wipe the oiler on one of your finger cots and there will still be enough oil to apply to something like the pallet stones.

Things to remember when oiling jewels: There should be a clear distinct ring of oil around the pivot. This, ideally, should be approximately one third of the oil sink's capacity. The oil should just be visible, with a slight ring of oil around the pivot (not a puddle of oil), and no oil on the top flat surface around the oil sink or on the top of the pivot.

Tip: If you have smeared the oil, do not be tempted to use Rodico to remedy the situation, even if the product is recommended for this purpose. I have found that it never works as a long-term fix, as the oil still seems to spread after about two weeks. For best practice, I recommend that the parts are degreased and then re-oiled. I have tried all the short-cuts and none of them works, as the oil always spreads. If you have a tendency to get oil on the flat surface of the jewel when applying it, try wiping one side of the oiler, and using this side on the flat surface. This does mean that you may need to reapply more than once, but there is still less chance of getting the oil where you don't want it to go.

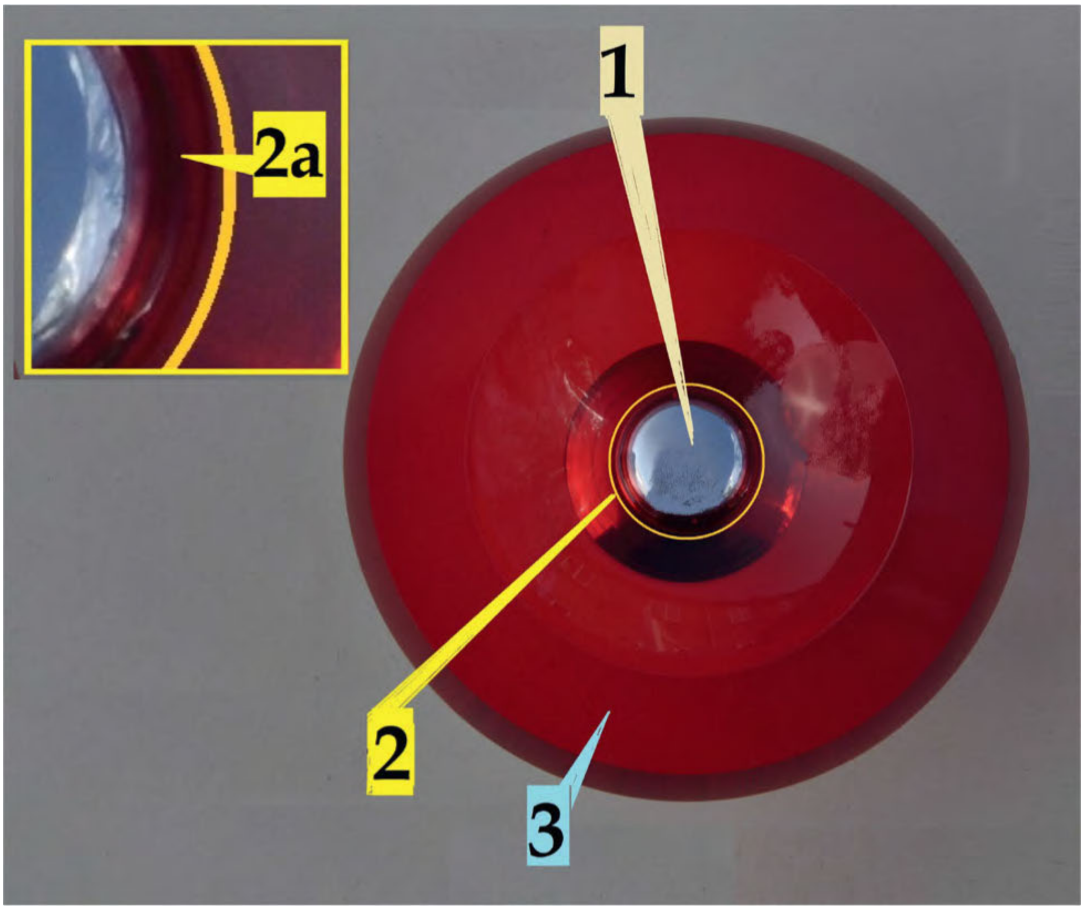


Fig. 201: Correctly oiled jewel (3). (1) Pivot, and (2) the amount of oil around the pivot. (2a) A closer look at the oil.

OILING A WATCH AFTER CLEANING

The Gear Train

Barrel and mainspring: Apply three large dots of grease to the inside of the barrel before fitting the spring, and give the same treatment to its cover. It is best to use Moebius 8200 (or Moebius D5 if you're on a budget). Before inserting the mainspring, remember to wipe clean the surface of the spring with degreaser or lighter fuel using a lint-free cloth.

Barrel arbor (first wheel): Before fitting the arbor in the barrel, apply Moebius D5/HP1300/ to the two middle shoulders. Fit the arbor in the barrel and then fit the cap. Next, apply a generous amount of oil (approximately two applications) to the large shoulder with the square, so you can see the oil. On the smaller pivot, apply a small amount of oil. We do this because the bearing that the arbor sits in is very thin, and there is a high amount of pressure due to the torque of the mainspring. A large quantity of oil would be pushed out.

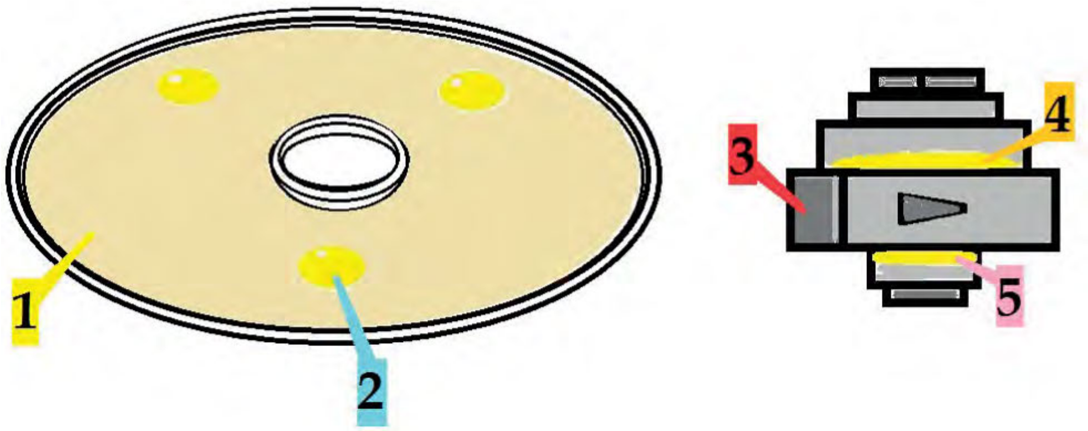


Diagram 21: Oiling of the barrel and its arbor. (1) Barrel cap. (2) Approximate amount of oil to place on the cap and the inside of the barrel. (3) Barrel arbor. (4) Place Hp1800/D5 oil here. (5) Place Hp1800/D5 oil here.

Centre wheel's (second wheel's) large shoulder: Before fitting the centre wheel into the main plate, you must apply MoebiusD5/9020 or HP 1300 oil to the large shoulder just after the pinion. It is important to do this as there is a high chance that when the cannon pinion is fitted, the oil may be sucked up in to the cannon pinion, leaving the centre wheel pivot dry if oiled from the front plate like a conventional pivot.

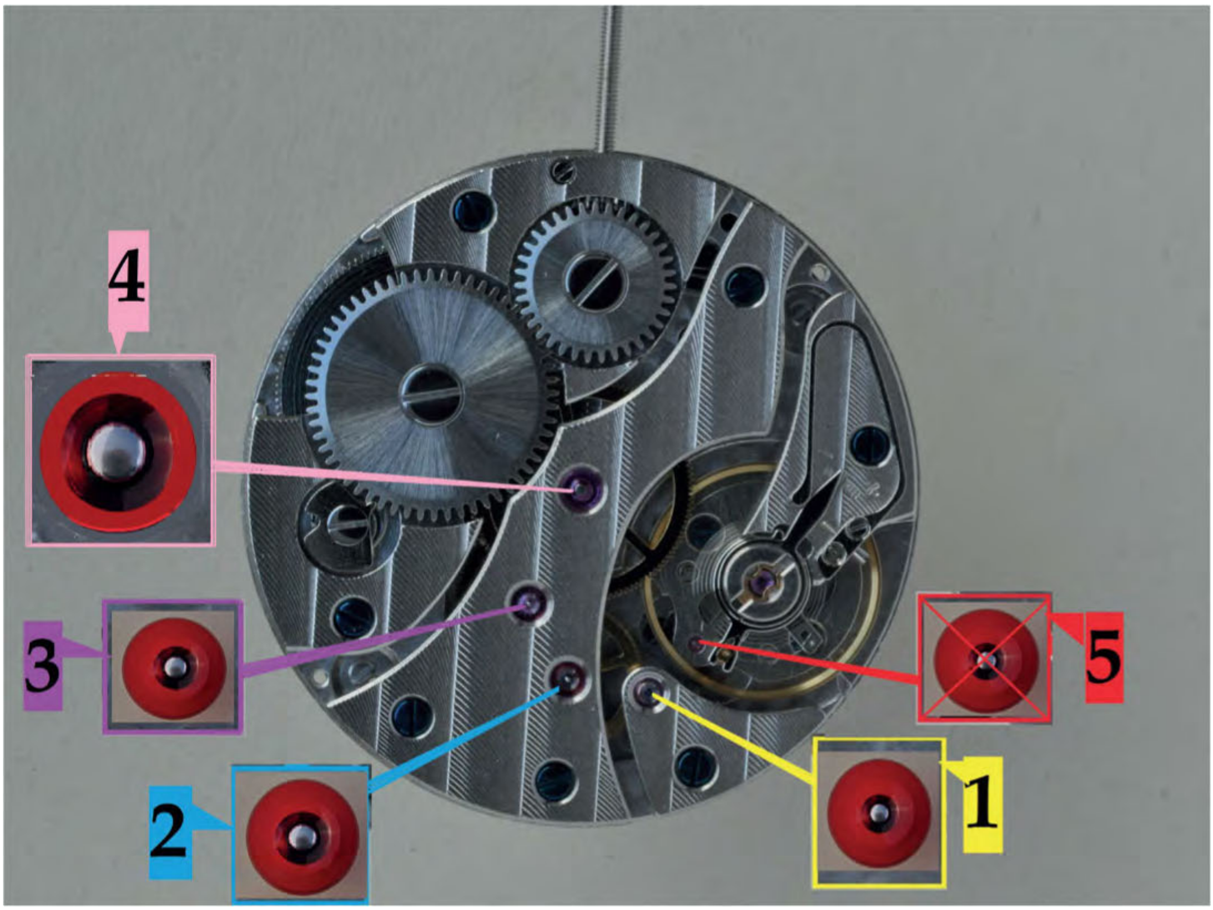


Fig. 202: Oiling table for the top plate: (1) Mobius 9010. (2) Mobius 9010. (3) Mobius Hp1300. (4) Mobius Hp1300. (5) No oil.

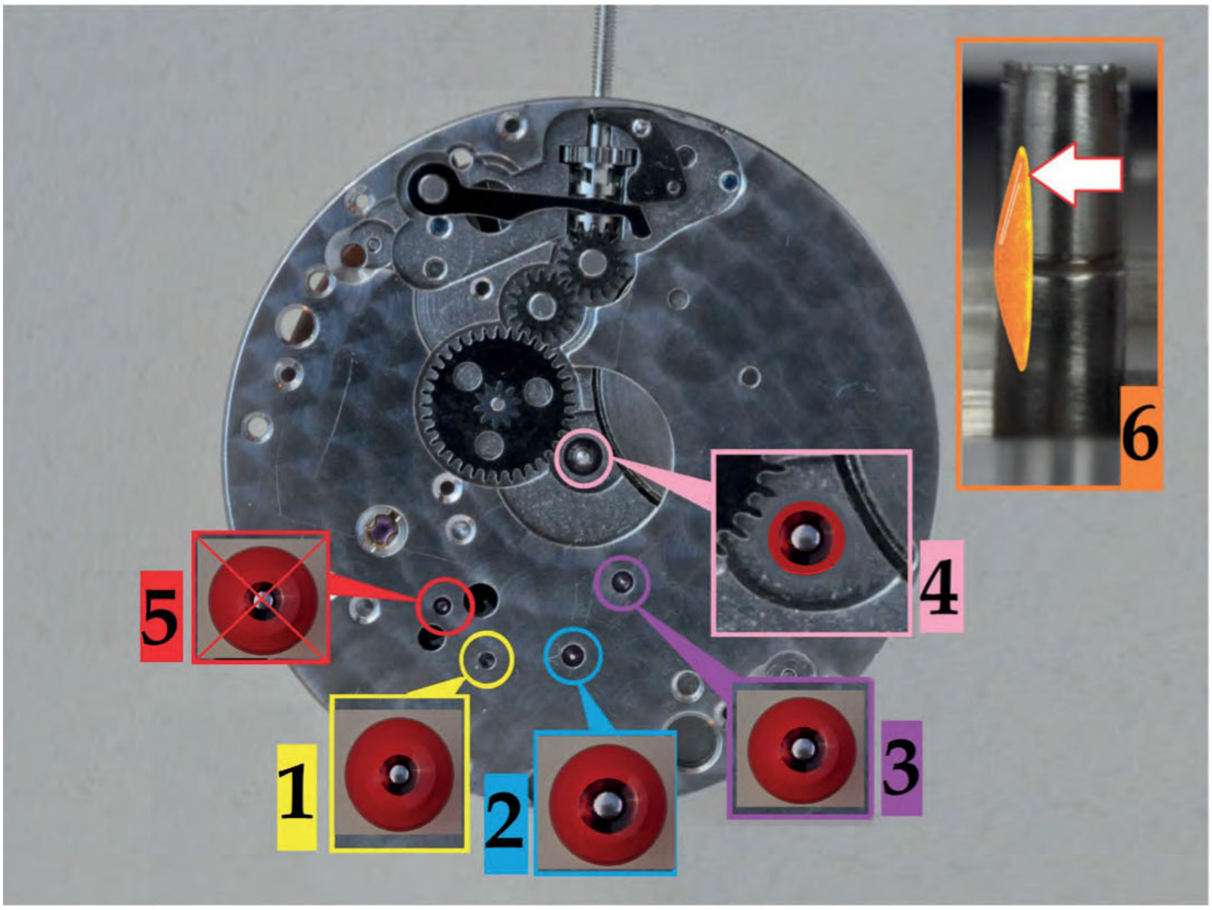


Fig. 203: Oiling instructions for the base plate: (1) Mobius 9010. (2) Mobius 9010. (3) Mobius Hp1300. (4) Mobius Hp1300. (5) No oil. (6) Mobius Hp1300.

Third wheel: Applied to both pivots back and front. I would recommend using Moebius 9010 for the smaller ladies' wristwatches.

Fourth wheel: Oil both pivots on both sides with Moebius 9010 on any size of watch.

The Escapement

Note: Before following these instructions, I would recommend that you first read the next section 'Detailed Oiling of the Escapement'.

Escape wheel (fifth wheel): Oil both pivots on both sides with Moebius 9010 on any size of watch. If you have Fixodrop 8941, remember to treat the escape wheel before fitting it into the watch (this is not an oil, and oil must still be applied before assembly).

The escape wheel is the only gear in a watch that ever has its teeth lubricated. This is applied to the impulse faces of the pallets, which transfer the oil to the escape wheel.

The lever escapement design flaw is that it has sliding friction due to the transfer of energy from the escape wheel to the pallets. To reduce this friction a small amount of lubrication is needed. The lubrication needs to be as thin as possible so as not to cause what I call 'sticktion' between the escape wheel and the pallets. The action of the escapement needs to be a fast twitch to keep the amplitude of the balance at the desired level. The amount of oil applied to pallets is incredibly minute.

Pallet pivots: In modern horology, the pallet pivots are always left dry. In pocket watches or early wrist watches made before 1910, I would recommend using a very small amount of oil on watches larger than twelve lignes. Use Moebius 9010 or Moebius 941.

Pallet stones: Use a small amount of Moebius 941 or Moebius 9415, depending on the speed of the gear train. Apply to the impulse face of the exit pallet stone. If you have Fixodrop 8941, remember to treat the pallet stones before fitting them in the watch.

Balance pivots: Apply Moebius 9010 to both pivots. If you have an older watch with fixed end stones, treat the end stones with Fixodrop 8941 prior to fitting, as this will help with the retention of the oil. The oil is applied to the jewel on the opposite side of the end stone directly into the oil sinks. The oil will need to be helped on to the end stone: to do this you will need a broken oiler sharpened into a gradual tapered point. Poke this into the pivot hole to break the surface tension of the oil, and you will see the oil disappear before your eyes. To check the amount of oil, look through the end stone at a slight angle and you will be able to see a distinct ring of oil. This must cover between 50–70 per cent of the surface area of the end stone.

To oil shock-resistant bearings, the same amount of oil is used, but this time the oil is applied directly to the end stone. Any residue left on the oiler is applied to the chaton jewel hole (this is further explained in the chapter on 'Cleaning and Oiling an Incabloc').

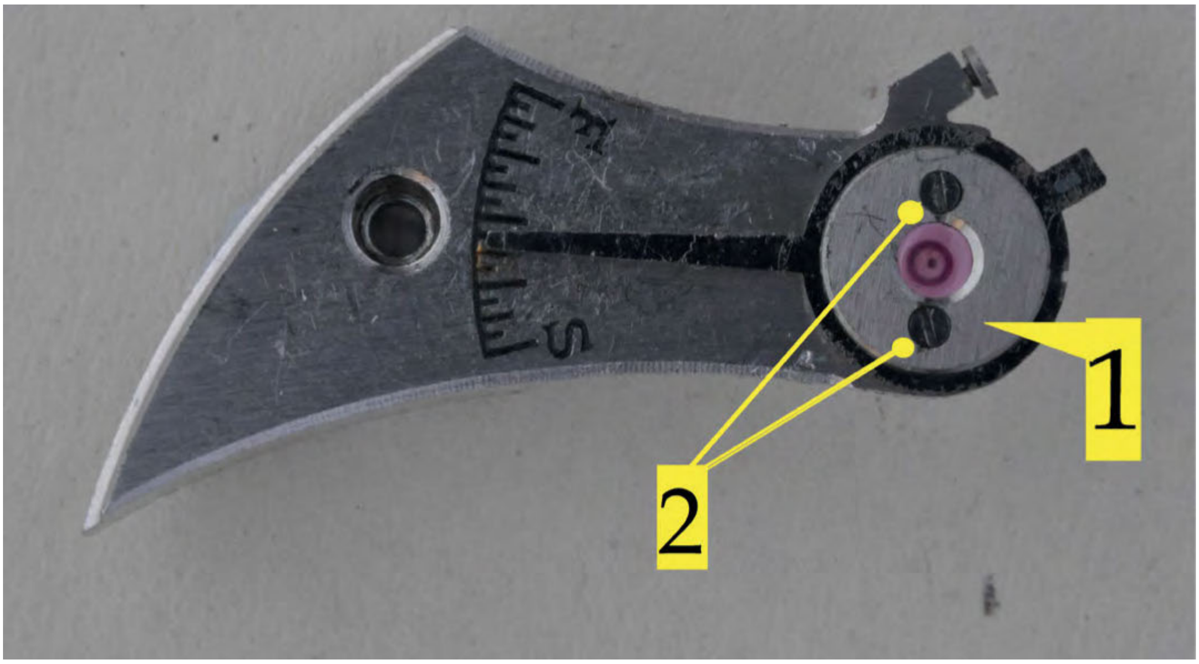


Fig. 204: Image 1: Fixed end stone. Image 2: Retaining screws.

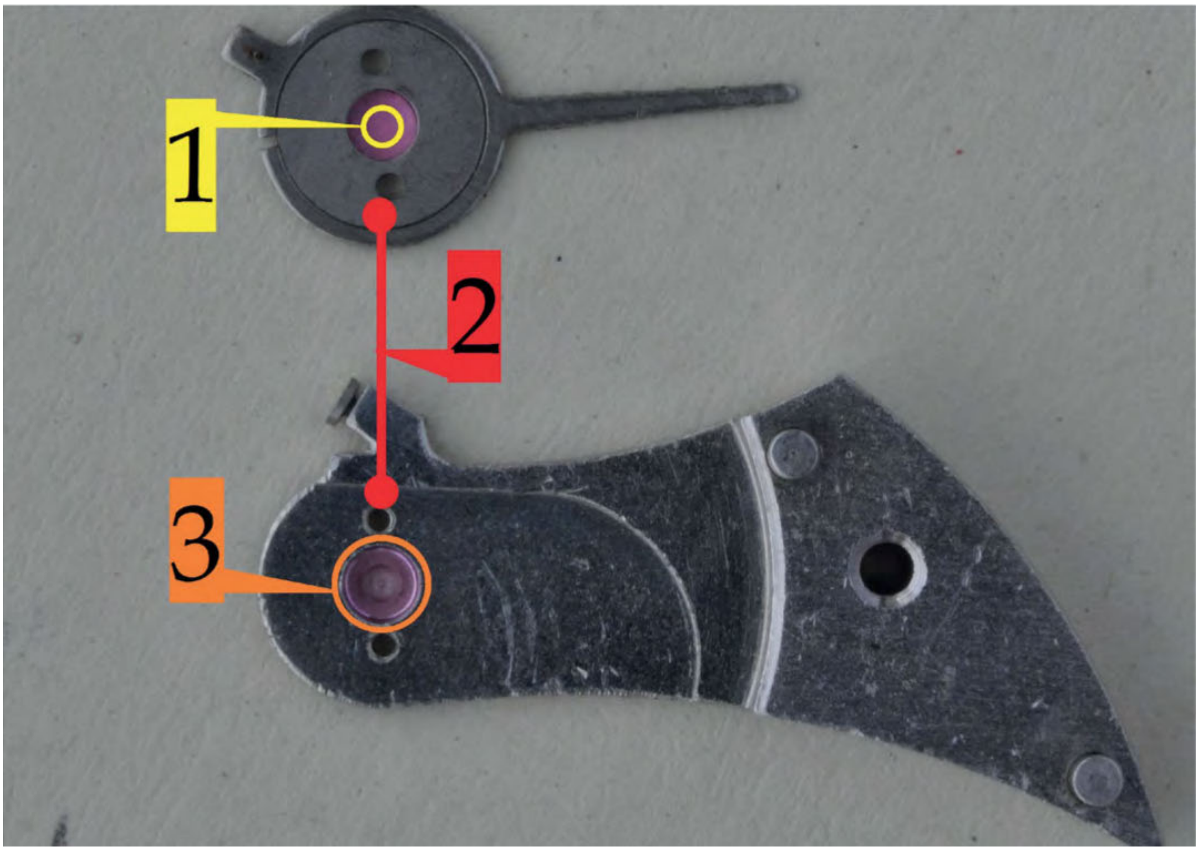


Fig. 205: Image 1: The amount of oil needed on the end stone. Image 2: Matching holes. Image 3: Balance staff jewel.

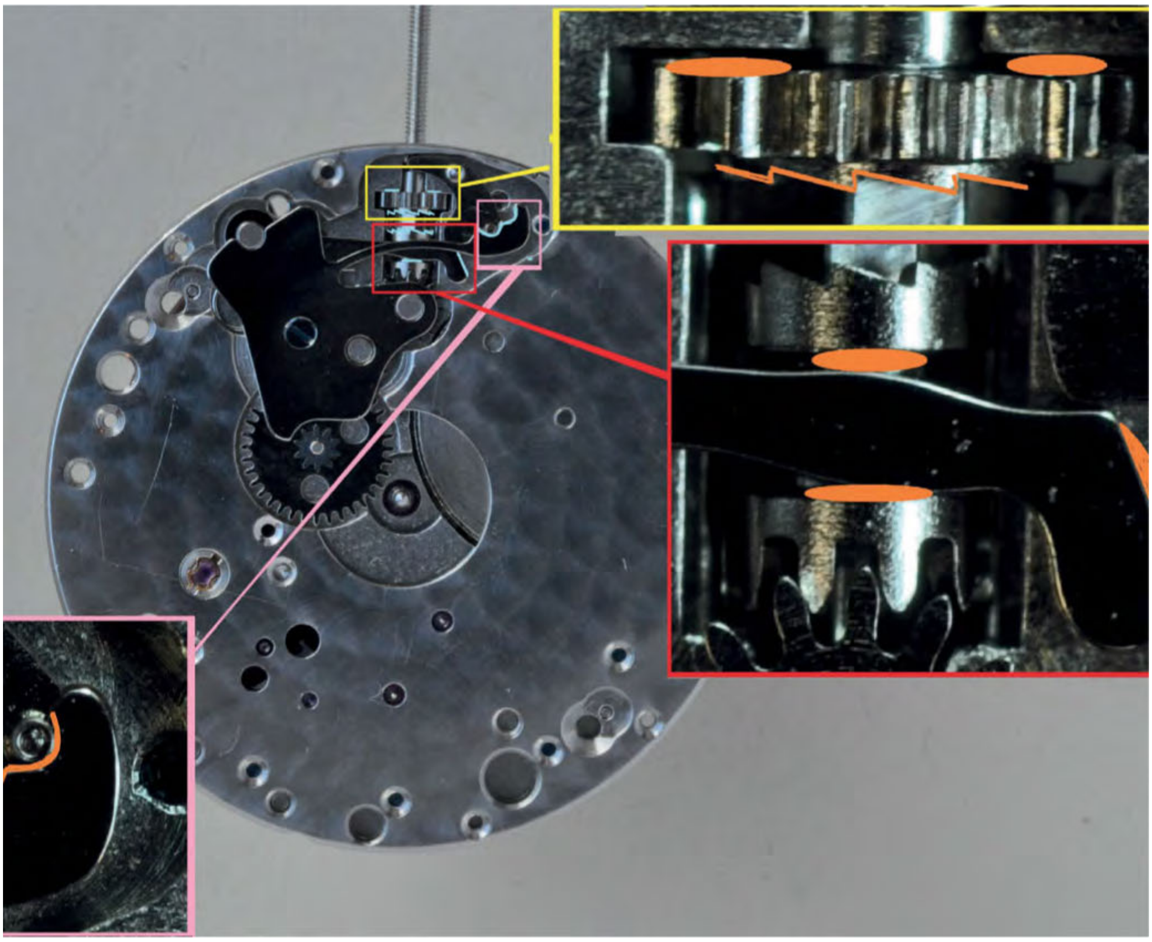


Fig. 206: Apply grease to all highlighted points on the keyless work.

Keyless Work

Bolt screw shoulder: Don't forget to fit the bolt screw in the main plate before fitting the barrel bridge. Apply a small amount of oil to its shoulder just above the screw thread. Use Moebius HP1300/D5.

Bolt spring claw and bolt pin: Use Moebius 9504 and apply sparingly. I like this grease as it is blue when applied, and after a month it turns white, making it very easy to apply, as you can almost paint it on the parts being lubricated. Alternatively, you can use very small amounts of Moebius HP1300/D5/8301.

Return bar: Oil where the bolt piece pushes on it, and where the return bar spring pushes on it. Use Moebius 9504/D5; all should be applied sparingly. Oil the post that the return bar rotates on, using Moebius HP1300/D5/8301.

Sliding clutch and winding pinion: Use Moebius 9504. Apply sparingly between the mating saw-shaped teeth. You also need to apply a small amount of lubrication to the part of the winding pinion that rubs against the plate. Put three small dots of lubrication on the teeth of the winding pinion that mate with the upper crown wheel. (Alternatively, use Moebius 8301/D5/ KT22.)

Winding stem: Apply Moebius 9504 sparingly to the pivot/square/shoulder, as well as the notch and the surface either side of the notch. This is pretty much all surfaces of the winding stem, except for the screw thread. Alternatively you could use Moebius D5/8301.

Upper crown wheel: Apply three small dots of Moebius 9504 to the inside wall of the wheel or the boss that holds it down. Alternatively, use Moebius 8301/D5.

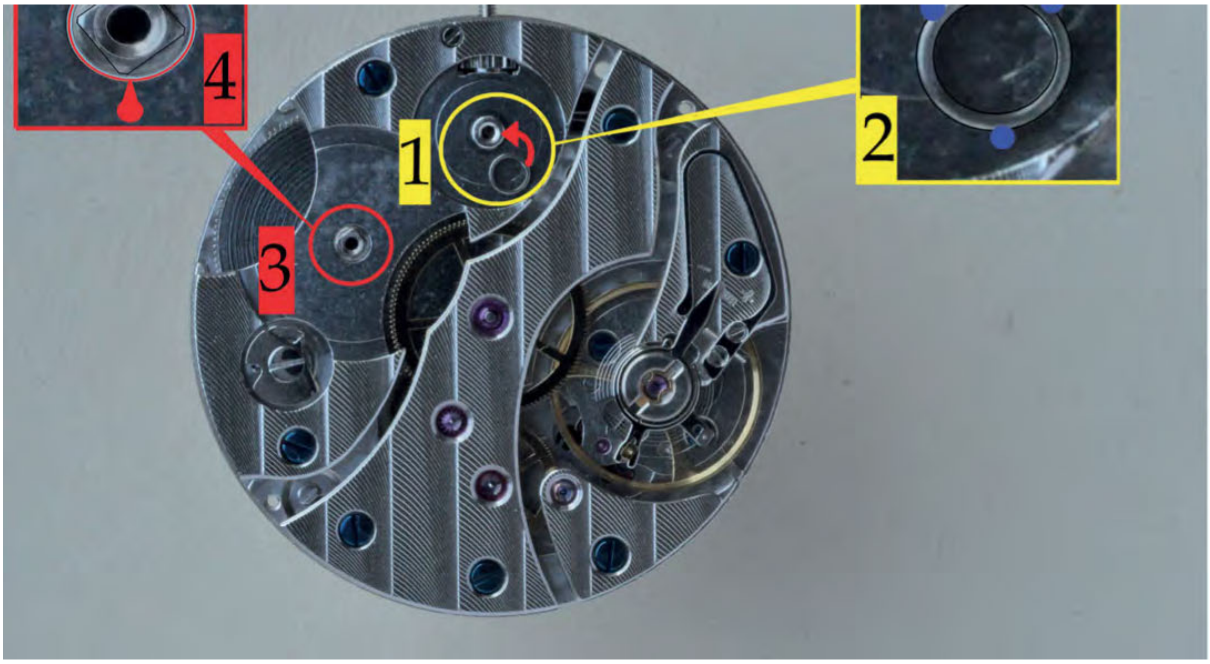


Fig. 207: Image 1: Remember to fit the upper crown wheel washer and apply three dots of grease or heavy oil (shown in image 2). (3 and 4) Apply Mobius Hp1300 to the barrel arbor.

Motion Work

Inside cannon pinion: Use Moebius D5 or HP1300 (Cannon wheels use 9501 or Moebius D5 mixed with 8301). Apply to the centre wheel post where the snap groove is located.

Tip: It's hard to advise how much oil to apply to the cannon pinion as this only comes through experience. However, apply too much and you will have no hand friction at all, too little and the cannon pinion may seize. My best suggestion would be to use half the amount you used on the barrel arbor shoulders.

Minute wheel post: A small amount of Moebius HP1300/D5 is applied to the post or the inside of the minute wheel.

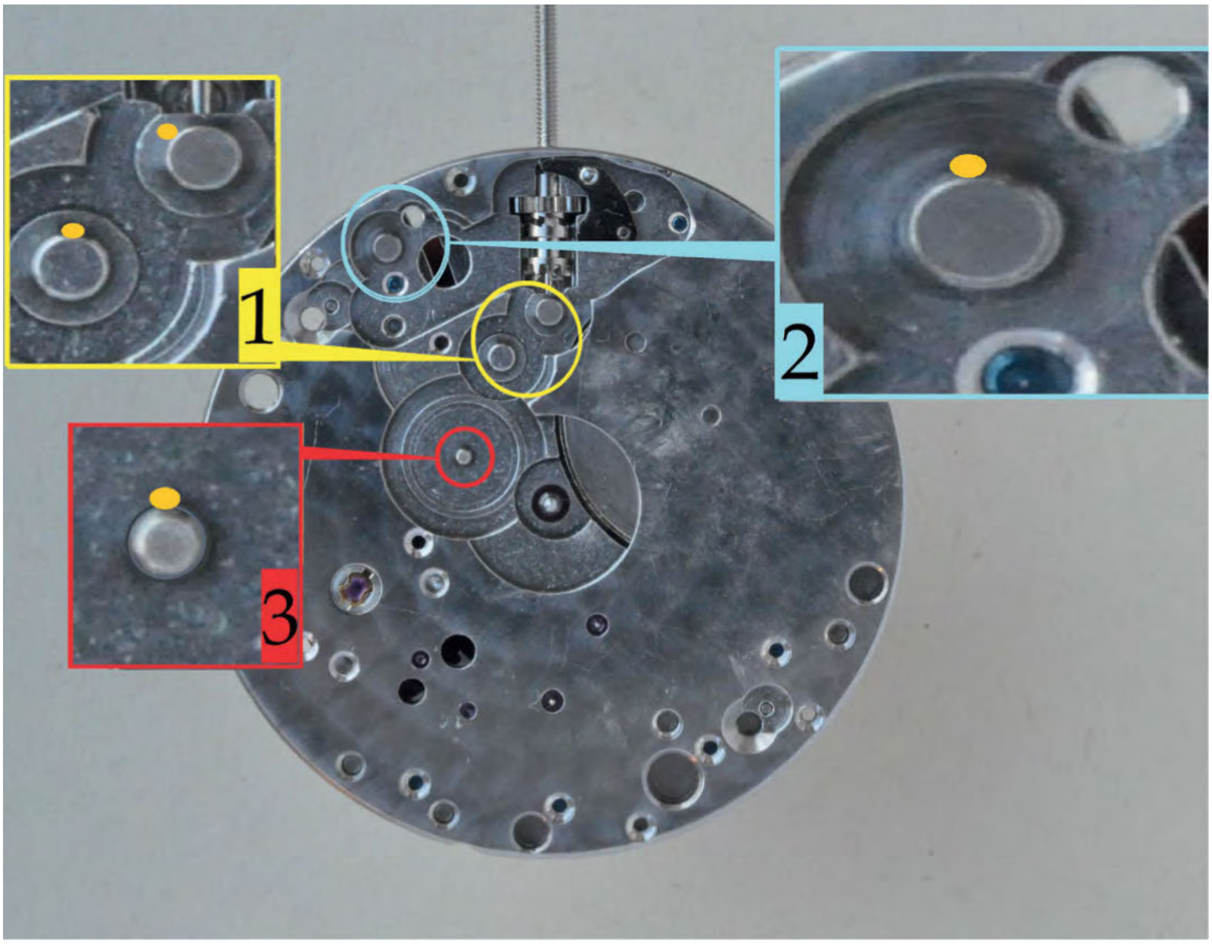


Fig. 208: Oil the highlighted posts with Mobius Hp1300.

Intermediate setting wheel (or wheels): A small amount of Moebius HP1300/D5 is applied to the post(s).

Hour wheel: A small amount of Moebius HP1300/D5/9020 is applied to the larger diameter of the cannon pinion or the inside of the hour wheel tube.

DETAILED OILING OF THE ESCAPEMENT

There are two oils and one grease that can be used on the escapement:

Oils: Moebius 941/2. These two oils are only used on watches that beat more slowly than 19,800bph. As far as I can tell they're both the same.

Grease: Moebius 9415 is used on the train of a watch that beats faster than 19,800bph.

The reason for using grease on the faster watches is that their fast-rotating escape wheel tends to 'throw' the conventional 941/2 oil, spraying it on the rest of the watch and leaving the pallets dry. This sprayed oil tends to end up on the surface of the balance spring, making the coils stick together and causing the watch to run extremely fast. The 9415 grease will stay put as it is not a conventional grease – it is oilier. It also thins down under pressure, helping it stick to the escape wheel and pallets.

Applying the Oil

This job is made easier with the watch wound and the balance wheel removed, as the escapement will be stationary. You will need the smallest oiler you have, as the oiling is going to take place at right angles to the impulse face of the pallet stone.

You can apply oil from above or below the baseplate (dial side) through two inspection holes that have been drilled into the plate for the purpose of oiling. Turn the watch over to the dial side, locate the Incabloc or end stone and look at the next jewel. This will be the pallet jewel. The inspection holes are offset, slightly diagonally to the pallet jewel. These 1.5mm (approximately) holes allow you to see the pallet stones and allow the oiler to pass through, meaning oil application to the pallet stone is much easier.

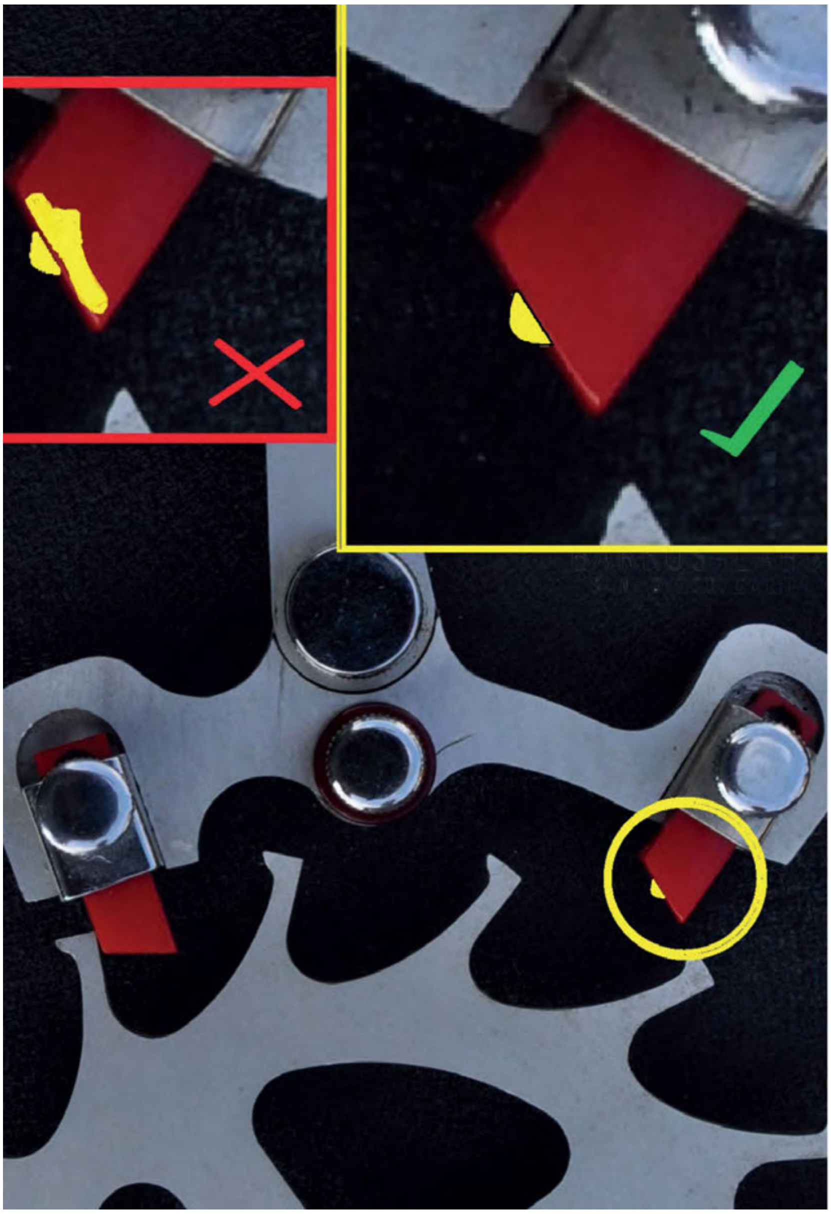


Fig. 209: Correct application of oil on the pallet stones.

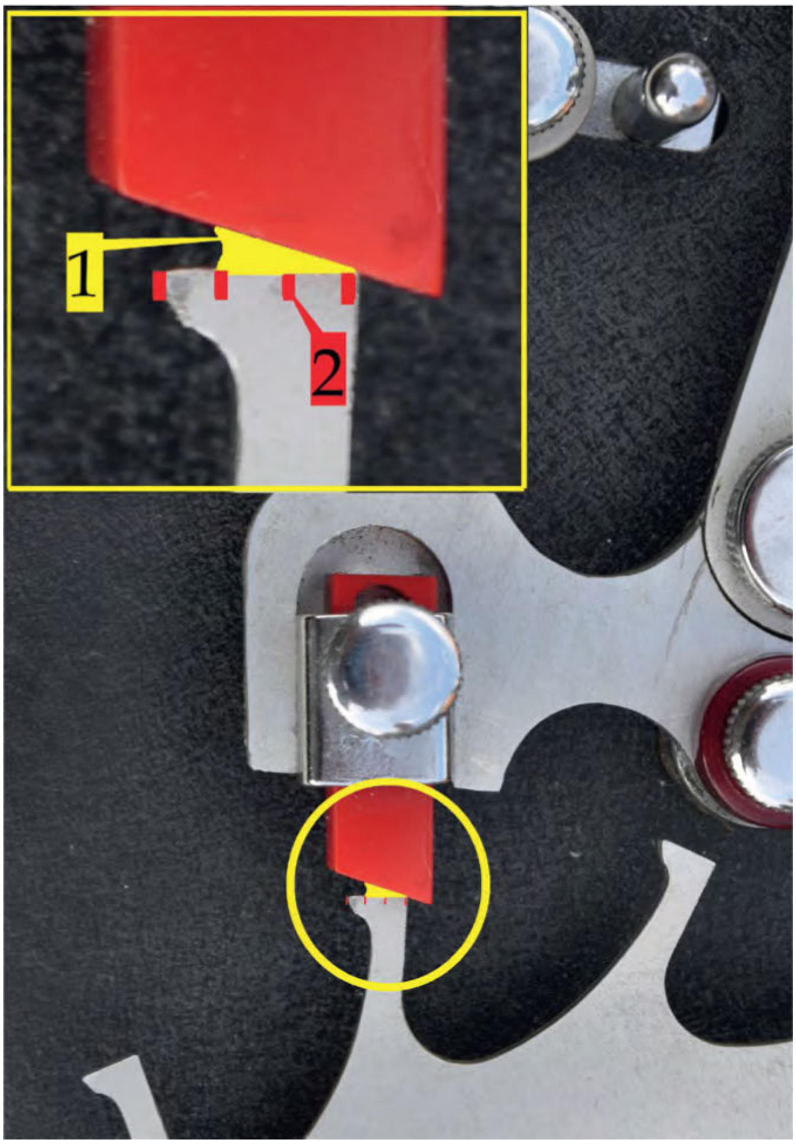


Fig. 210: Correct amount of oil. Image 1 shows the position of the 2/3rds of oil. Image 2 shows the impulse plane divided in three parts.

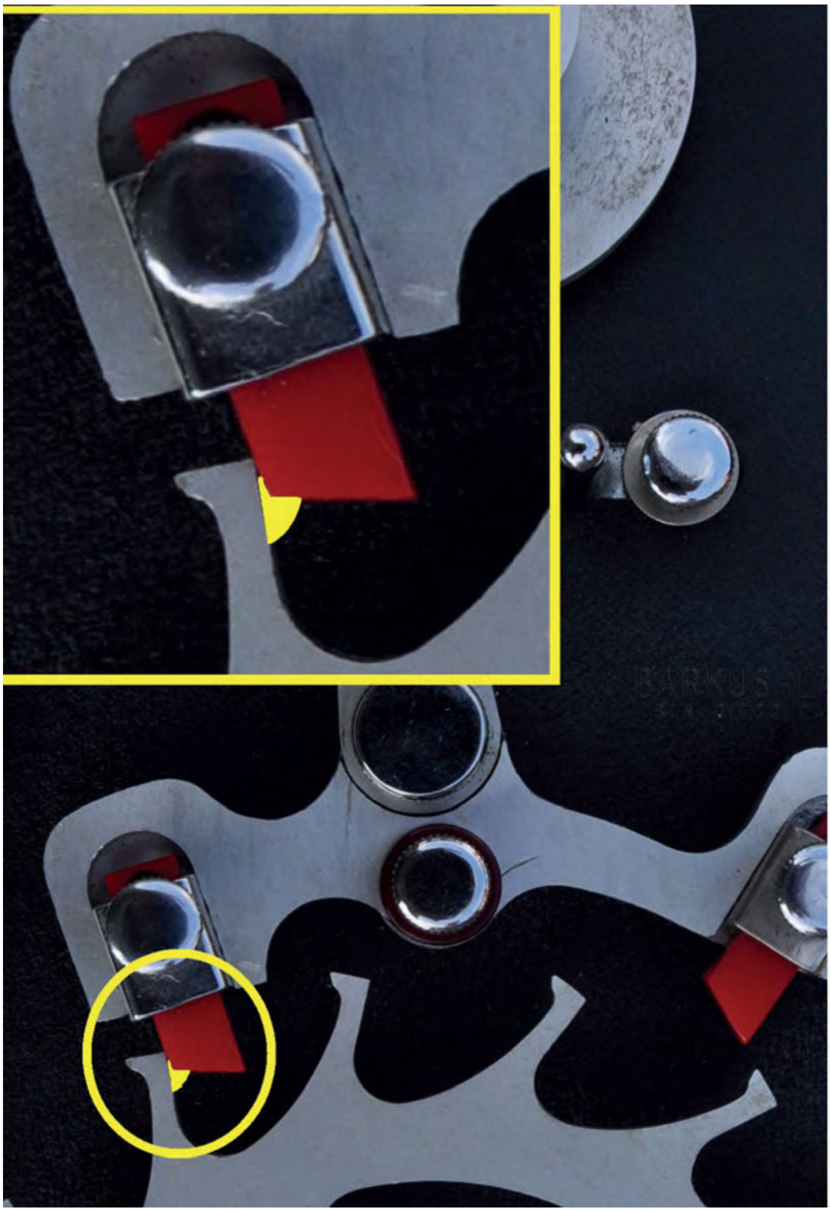


Fig. 211: Alternative method for checking the correct amount of oil.

It is the norm to apply the oil to the exit stone’s impulse plane. This is best delivered in small amounts. I find it best to pick up a small amount of oil on your oiler, wipe some of it off on to the top of your finger cot, and then use the oiler to apply it to the stone. Flick the pallets left five teeth and right five teeth manually. Reapply the oil. Repeat the movement twice.

If the oil has been properly applied, it should look something like Fig.209, where oil is only present on the impulse faces of the pallet stones, the impulse faces of the escape wheel teeth, and the locking face of the escape wheel. There should be none anywhere else.

Another reason for checking if you have applied the correct amount of oil to the pallets can be seen when impulse is given. The oil will form a 'V'-shaped bubble between the pallet stone and the impulse plane of the escape wheel tooth. This is seen at the moment of impulse. The correct amount of oil should fill between one third and two thirds of the length of the escape wheel's impulse plane. If you see oil on anything other than the impulse plane or the locking face, then you will have to clean the pallets and escape wheel in a degreaser and repeat the operation until you get it right.

The Use of Fixodrop on the Escapement

Best practice would be the application of Moebius Fixodrop 8941. This is a treatment made to prevent the spreading of oil on metal. It has been used in watch repairing for many years and makes for easy application of oil to the pallet stones. It also keeps the oil in place for much longer and is very commonly used in service centres. Put simply, Fixodrop is applied to the area where oil is not to be applied on the escapement. This means that when the oil is applied, it will all be 'attracted' to the spot where Fixodrop isn't present. If you really struggle to get the application of oil on the pallets correct, this may be the way for you to go! Fixodrop is not cheap and has a very low evaporation point, so when you decant it, only collect a thimbleful in an air-tight container. If used carefully, this amount can treat thirty or more watches.

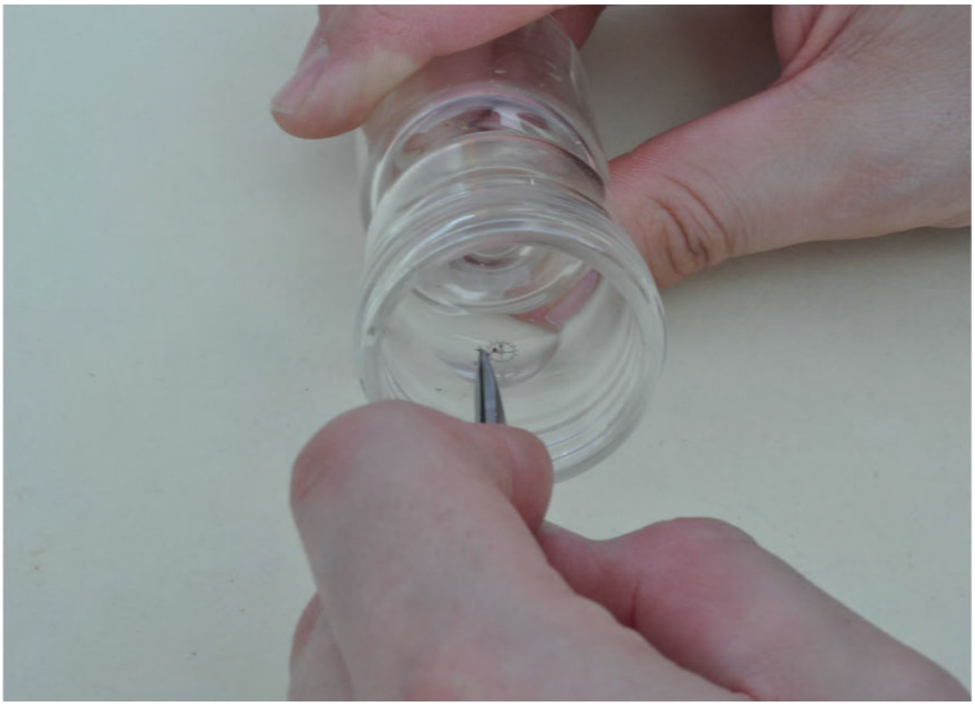


Fig. 212: Treating the pallet jewels and escape wheel with Fixodrop.

Ideally, Fixodrop is decanted into an hour glass-shaped bottle (as shown in Fig.210). The advantage of this bottle is that it reduces the evaporation rate of the Fixodrop, as well as being useful for its application. This bottle is normally used in conjunction with a plastic sieve-type basket, popped into the large chamber in the bottle with the lid screwed on. The bottle is turned over and the parts are left to soak in the solution for a short time. Once the parts are removed from the bottle they are then dried in a stream of warm air (usually a hairdryer). This prevents any damp air being trapped between the metal's surface and the application of the Fixodrop, as this may cause surface rust later on.

Some professional watchmakers treat multiple parts in Fixodrop, and this is why a basket is used. The problem with this is that the basket is also treated with the product, meaning the Fixodrop gets used up much more quickly. I prefer not to use this method for exactly this reason. Instead, I use the hour-glass bottle by shaking a small puddle of the liquid into the top chamber with the lid on. Next, carefully unscrew the lid (keeping the Fixodrop in the topchamber). Hold the bottle at a slight incline, and then just dip the escape wheel in the solution for a few seconds. Dry the object in warm air. Treat the pallet stone in the same manner.

Once you have refitted both the pallets and escape wheel and there is power in the gear train, flick the pallets left and right for one complete revolution of the escape wheel, as this will chip off the Fixodrop from the impulse planes of both the pallets and escape wheel where they make contact.

Warning! Fixodrop must not be applied to the pallet pivots or fork area. Only the stones must be treated, otherwise this will lead to excessive wear. You must not forget to apply oil to the pallet stones because otherwise the watch will grind to a halt within twenty-four hours. This certainly helps to remind you to oil the pallets!

Oiling the Pallet Stones

Dip the oiler into your pallet oil (remembering to wipe off some of this on to the top of your finger cot).The oil is best applied to the exit stone. As you will probably see, it tends to form a peak on the first four escape wheel teeth, due to the application of Fixodrop. These little blobs of oil can transfer on to the belly of the pallet frame, which will then spread on to the balance spring, making the coils stick together and causing the watch to run very fast.

You will also notice that as the oil is applied to the pallet stone, it is almost as if it is attracted to the impulse plane of the pallet. This is because the Fixodrop is only present on the outer edges of the impulse plane. Oil will have to be applied two or three times, until the desired amount of oil is present, just as if you weren’t using Fixodrop.

Tip: Instead of applying the oil (with Fixodrop present) to the pallet stones, you can apply it to the teeth of the escape wheel’s impulse planes, as the Fixodrop has been removed from these impulse planes. Some people find this much easier.

Warning: If you immerse the whole of the pallet frame in Fixodrop this will have the adverse effect of wearing out the impulse pin. This is due to the Fixodrop being present in the notch of the pallet’s frame, and this eventually turns into a powder, which will slowly grind down the impulse pin. If any powder residue is left on the escape wheel and pallets, this is not an issue as it is made inert later on, when mixed with the oil applied to the pallet stones. If you accidently dipped the whole frame into the Fixodrop, you can remove it by rubbing the surface with some peg wood and cleaning off any residue with degreaser.

Tip: Replace the bottle’s lid as soon as possible. When storing your decanted Fixodrop, keep it out of direct sunlight and in a cool place to prevent it from evaporating. Fixodrop bottles can be quite expensive, so any small airtight container can be used (such as a mini jamjar). Alternatively they can be purchased directly (and more cheaply) from A1 Scientific Instruments in Enfield.

AUTOMATIC OILERS

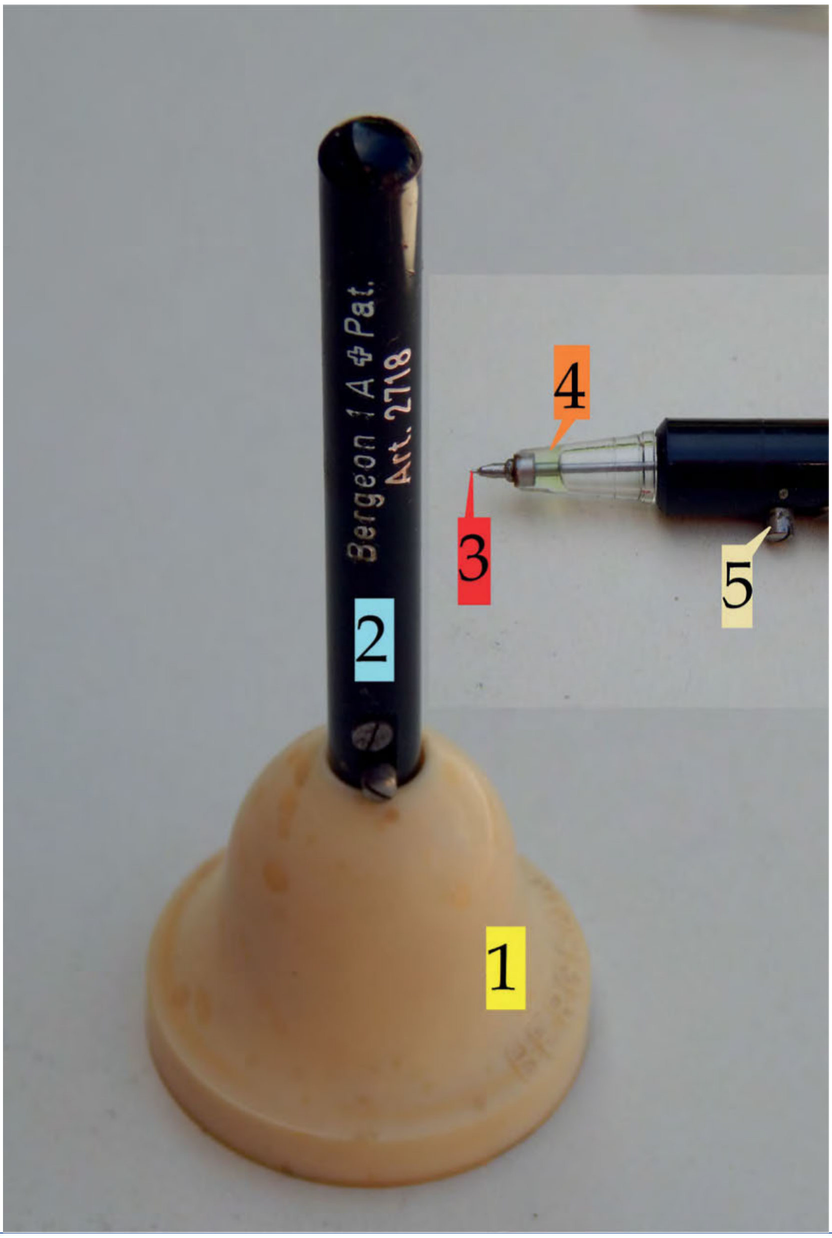


Fig. 224: Bergeon auto oiler for end stones. (1) Stand. (2) Oiler pen. (3) Oiler nib. (4) Oil reservoir. (5) Button to apply the oil.

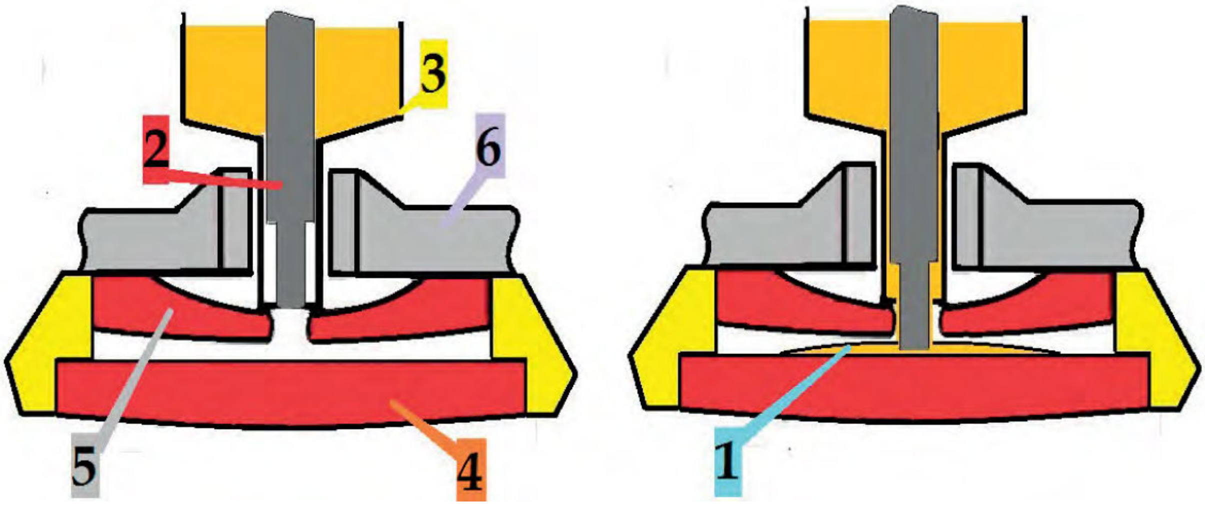
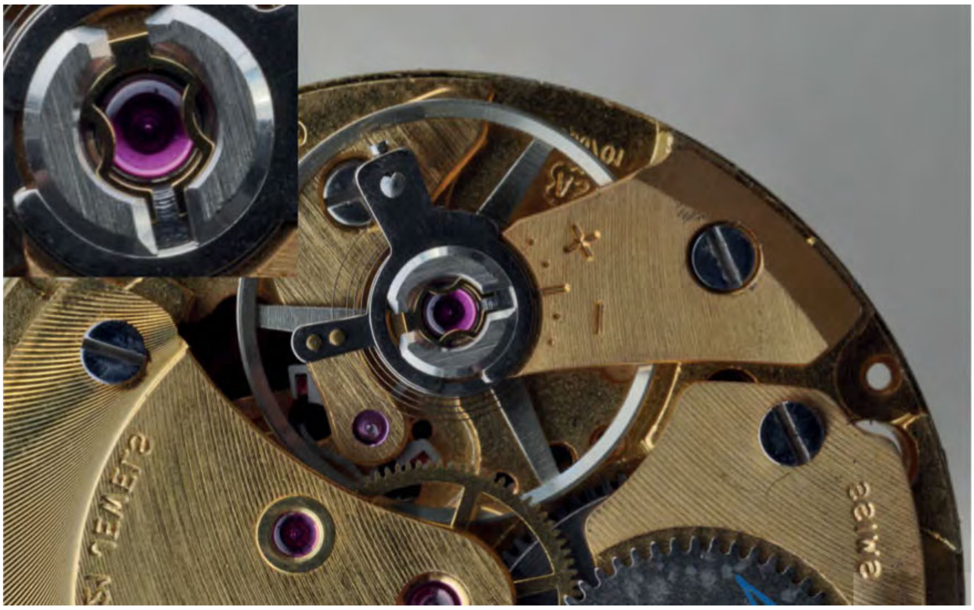


Diagram 22: How Bergeon's automatic oiler works. (1) Oil applied. (2) Oiler nib. (3) Oil reservoir. (4) End stone. (5) Chaton jewel. (6) Chaton.

This is a tool made by Bergeon, model number 2718-1a, designed to oil shock-resistant settings. It can be used on all shock-resistant bearings in watches, and balances and escape wheels fitted with shock-resistant jewels. It is a pen-type device that, with a press of a button, can place a controlled blob of oil on the end stone's surface. The tools have a fine needle tip, smaller than that of a standard balance pivot, which dips in and out of an oil reservoir. The amount of oil it delivers can be controlled with an adjusting screw. This basically limits the movement of the needle. It can be used in two ways: the first is without removing the shock-resistant bearing from its setting by injecting the oil into the setting though the pivot hole of the chaton. The second method is to assemble the cleaned end stone and chaton dry, and then inject the oil through the pivot hole in the chaton.

Tip: When using this tool, the tip applicator is easily damaged when you remove it from its holder, and the replacement tips are quite expensive for what they are. The easiest way to avoid this is to retract the tip before removing it from its holder. Hold the tip in this position, clean the business end with some Rodico, then put the tool in the setting to be oiled and let go of the button. And hey, presto! There it is, oiled!



32. CLEANING AND OILING AN INCABLOC

Fig. 213: Incabloc.

To clean the Incabloc, you have to remove the chaton and the end stone. To do this you must first unclip the retaining spring. The best tool for the job is a broken small oiler (if you have one), with the broken end filed to a point using a diamond file. Alternatively, a fine pair of tweezers (No. 3 or No. 5, preferably brass) will also do the job. You should release the captive parts of the retaining spring by pushing each prong towards the other. This must happen one at a time, so that the spring can be hinged back to release the chaton. You should notice that the spring is held in the setting by the T-part of the spring, which acts as a hinge.

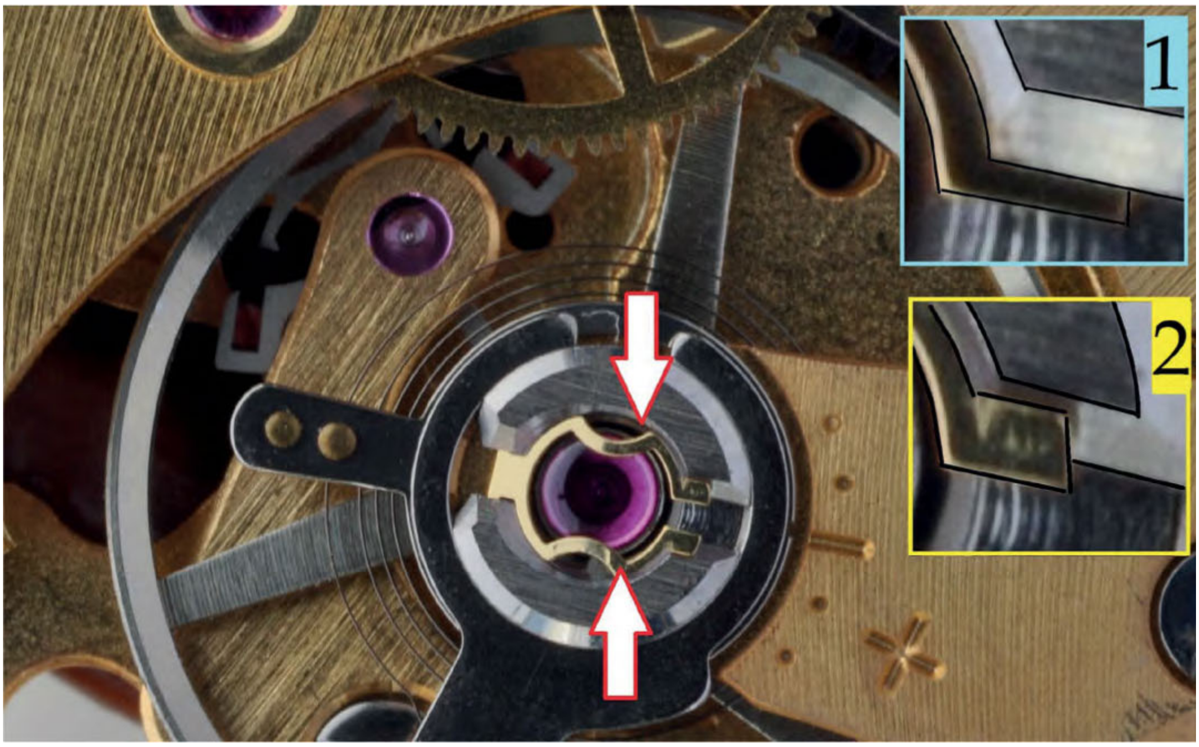


Fig. 214: To release the captive spring, carefully tease the sides of each part of the spring as indicated by the arrows. Image 1: The ends of the spring captive. Image 2: The spring unclipped.

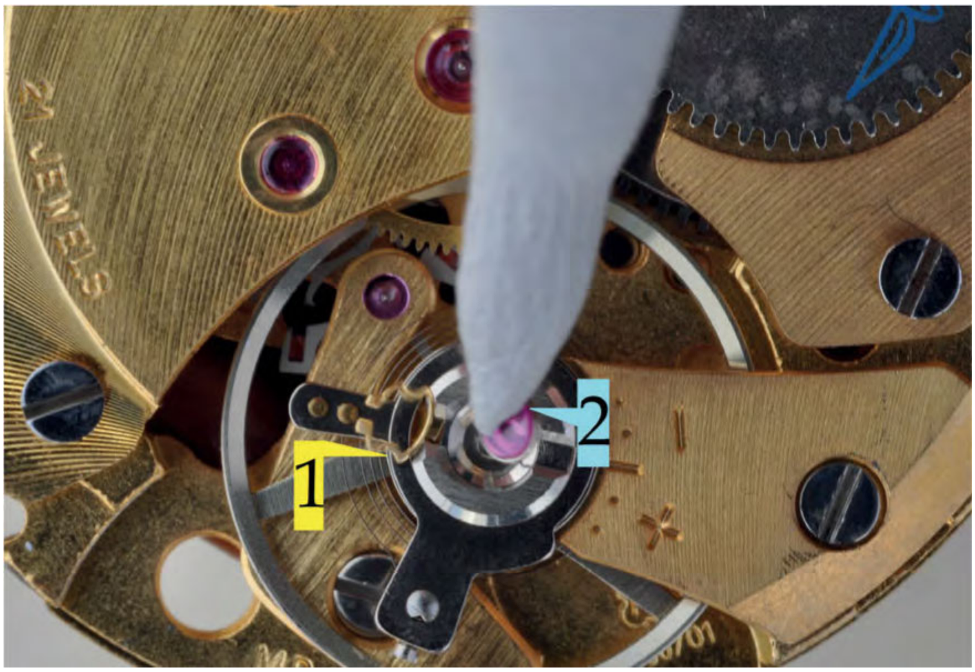
Tip: Make sure you only apply *very light* pressure to the *very end* of the spring, as close as you can get to where it is captive. Only pull it back far enough to release each prong, as they are very easily damaged or broken. If you have the Chinese Seagull movement, the Incabloc spring will only hinge back about 45 degrees, and you may need to use a piece of Rodico pushed on to the balance cock to hold it open.

If you are unfamiliar with a particular watch, and you don't wish the spring to fall out of its setting as you open it (as the occasional watch has a nasty habit of doing), I would recommend putting a small blob of Rodico just behind the spring to support it when it is open. Allow it to open up no more than 80 degrees: this will stop you having the headache of trying to refit it, as this is a very fiddly procedure.

Once you have successfully released the spring, swing it open. Roll the end of a small piece of Rodico to a tapered point, and use this to lift out the chaton from the setting (you can use tweezers, but not without the severe risk of the chaton flicking out of them). Once the chaton is free and placed in a safe place, hinge the Incabloc spring closed, to prevent it from being damaged during cleaning.

Tip: To save time you only need close one end of the spring back into the setting to hold it in place for cleaning.

Tip: If you do not intend to clean the watch straightaway, I would highly recommend keeping the chaton and end stone separate from the rest of the watch, as they like to play hide and seek.



They have a habit of sticking to various parts of a disassembled watch and disappearing.

Fig. 215: (1) Hinge up the spring. (2) Lift out the chaton with some Rodico.

REMOVING THE KIF

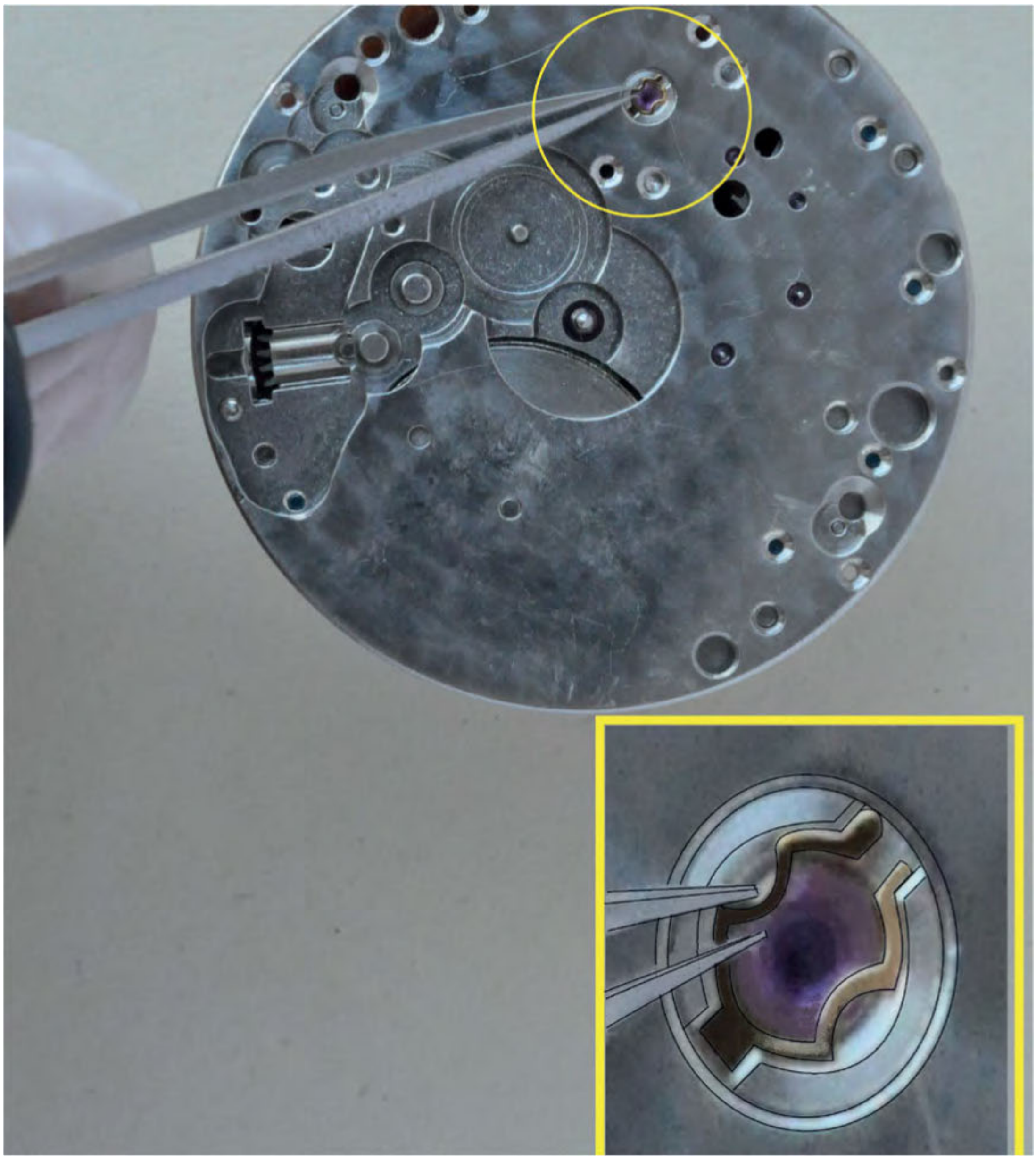


Fig. 216: Remove the base plate Incabloc in the same manner.

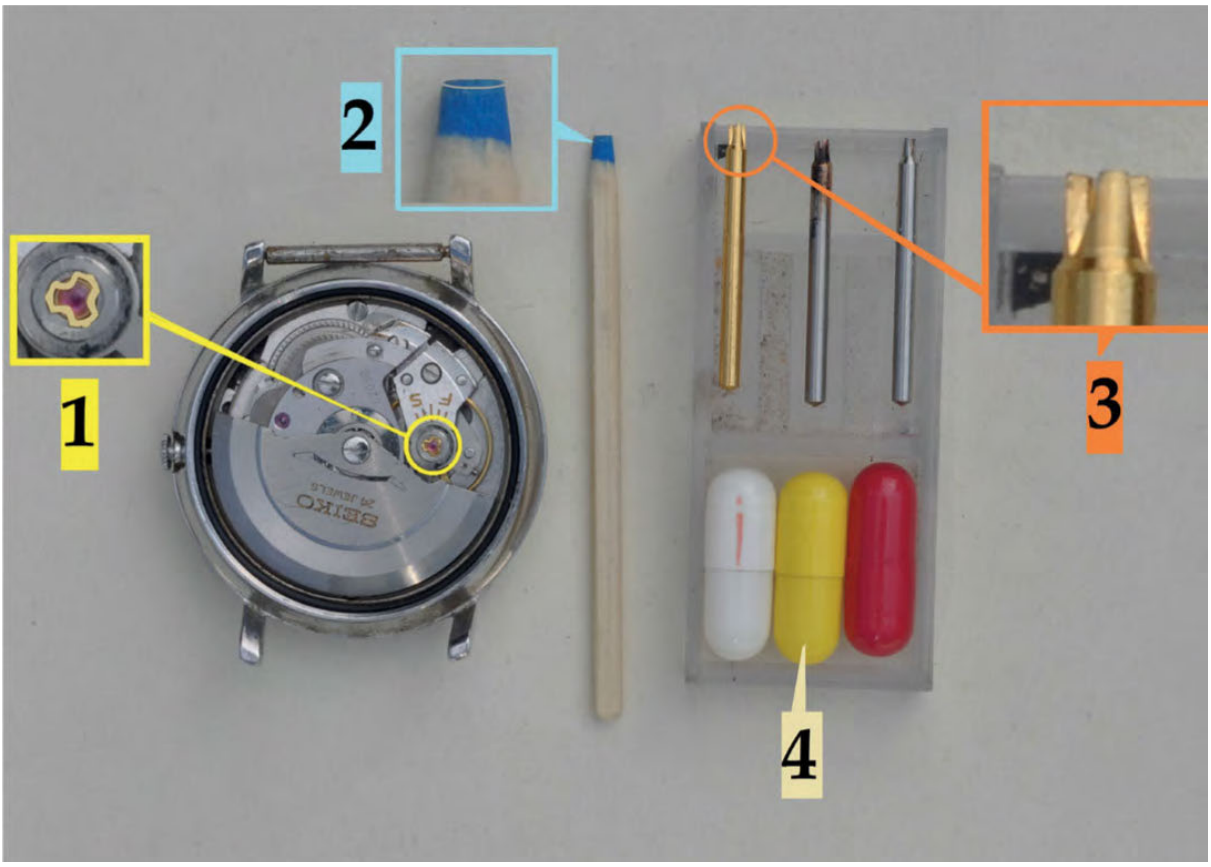


Fig. 217: Image 1: A Seiko with a Kif shock setting. Image 2: Homemade Kif removal tool. Image 3: Factory tool. Image 4: Spare springs.

To remove the chaton and its jewel for cleaning/oiling, you have to remove the Kif spring (seen in Fig. 217), shaped somewhat like a pronged three-leafed clover. This can be done by using a Kif tool, which looks rather like a screwdriver blade with a three-prong tip. Alternatively, we can make a temporary tool using peg wood. Take a screwdriver that is slightly smaller than the round Kif spring, and use this as a drill to make a hole in the end of a piece of peg wood. Then with a file, bevel the edge so that the tip of the tool is about the same size as the outer edge of the Kif spring.

Once you have a tool adequate for the job, place it over the Kif setting and press down on the spring with light pressure, and then twist, so that the wings on the edge of the spring can escape though the cut-outs in the setting. If you wish to keep this tool for future use, simply apply a coating of acrylic paint to the tip.

Kif settings have one, two or three cut-outs for the wings of the spring to escape, so if you have only one, you have to let each wing jump up and then twist further until the second wing jumps out of the setting. Once the spring is free of the setting, pick it up using a piece of Rodico and place it in a pot for safe keeping.

Tip: The spring doesn’t need cleaning, so keep it separate from the rest of the watch. They have a habit of sticking to other parts of the watch and they tend to get lost.

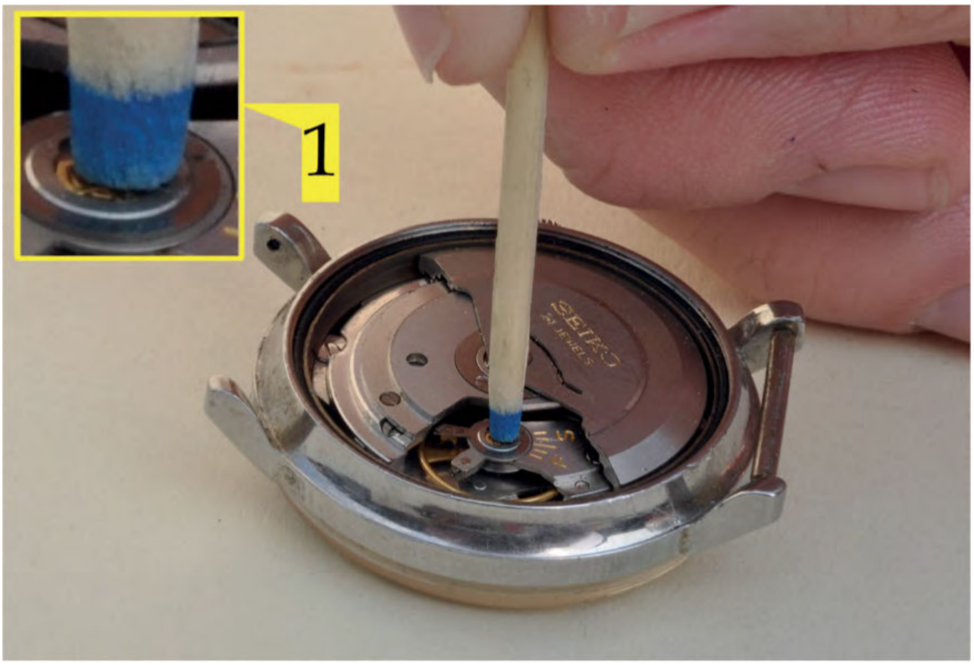


Fig. 218: Removing the Kif spring.

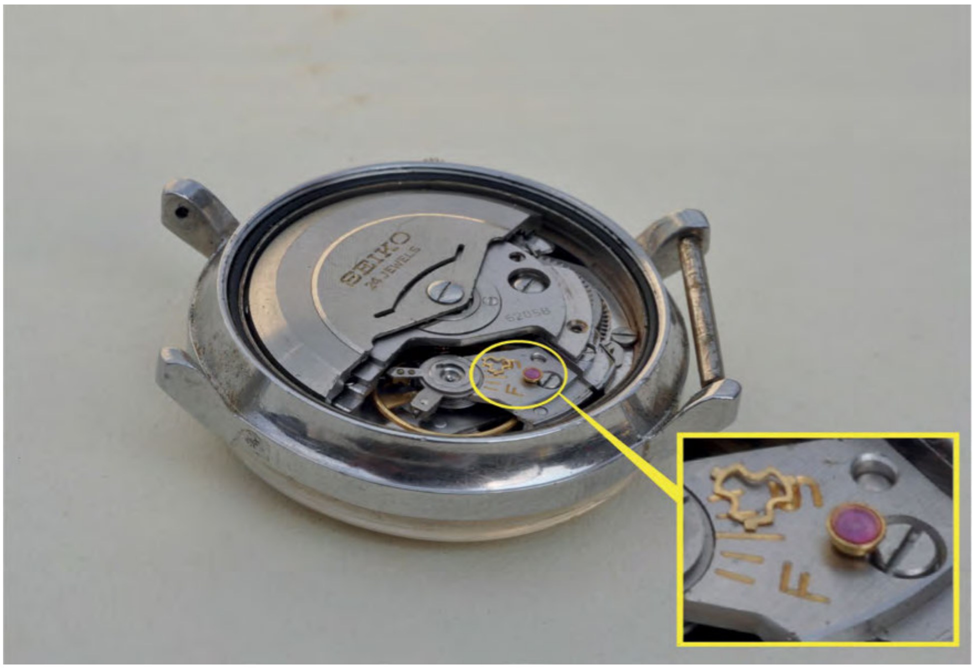


Fig. 219: Removed spring and chaton.

CLEANING THE INCABLOC

Drop the chaton and the captive end stone into a small pot of watchmaker's de-greaser. It will only need a few minutes to clean the chaton and its end stone, and they will normally separate into two parts. When lifting the end stone out of the degreaser, it is good practice to make sure the tips of your tweezers are nice and straight. It's also a good idea to slightly roughen up the inside of the tips, to prevent the end stone flicking out of your tweezers.

Once you have lifted the end stone and the chaton out of the degreaser, place them on a piece of tissue paper. Ensure the flat of the end stone lies on the paper, as this will drain off any surplus degreaser (or use a puffer to dry it). Make sure that the two parts are free of dirt and smears, using the degreaser again if any are present. If the old oil is stubborn, you can wipe the flat of the end stone on a piece of paper or on a leather buff stick, then re-dip in the degreaser and dry off.

Tip: If the end stone and the chaton fail to separate in the degreaser, you can use Rodico to help pull the two apart by holding the chaton with your tweezers and pushing the end stone side into the Rodico.

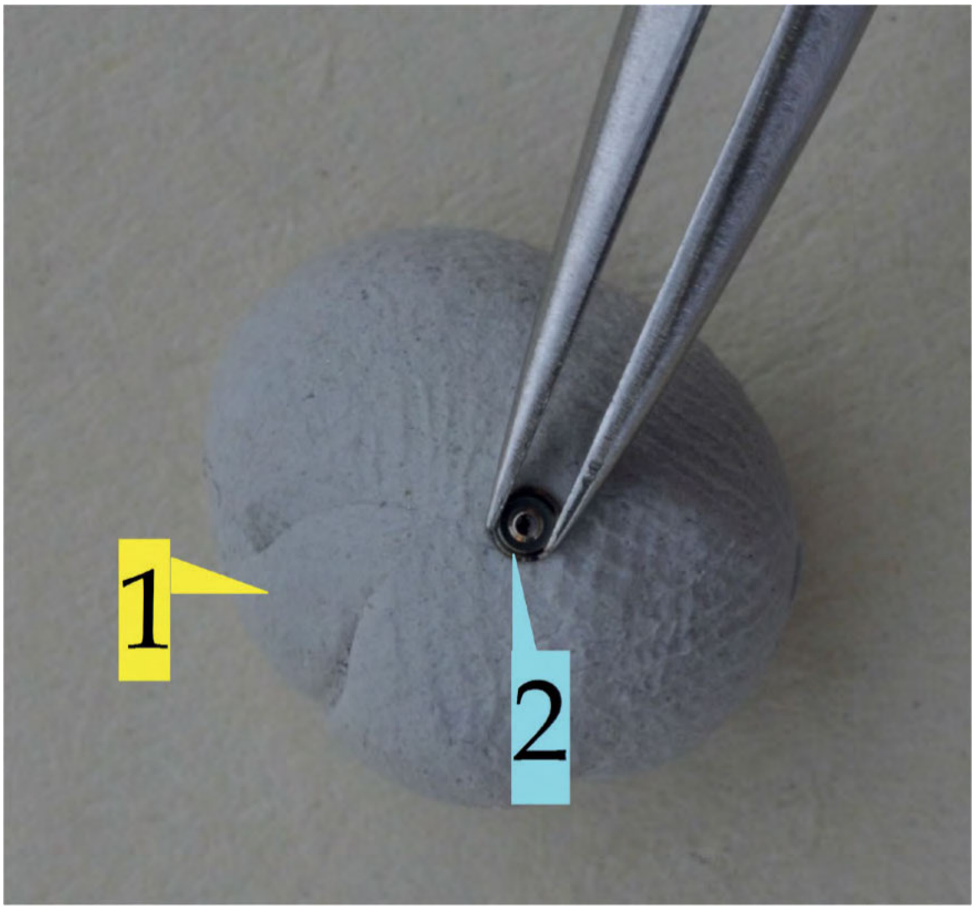


Fig. 220: Separating the chaton and end stone (2) using some old Rodico (1).

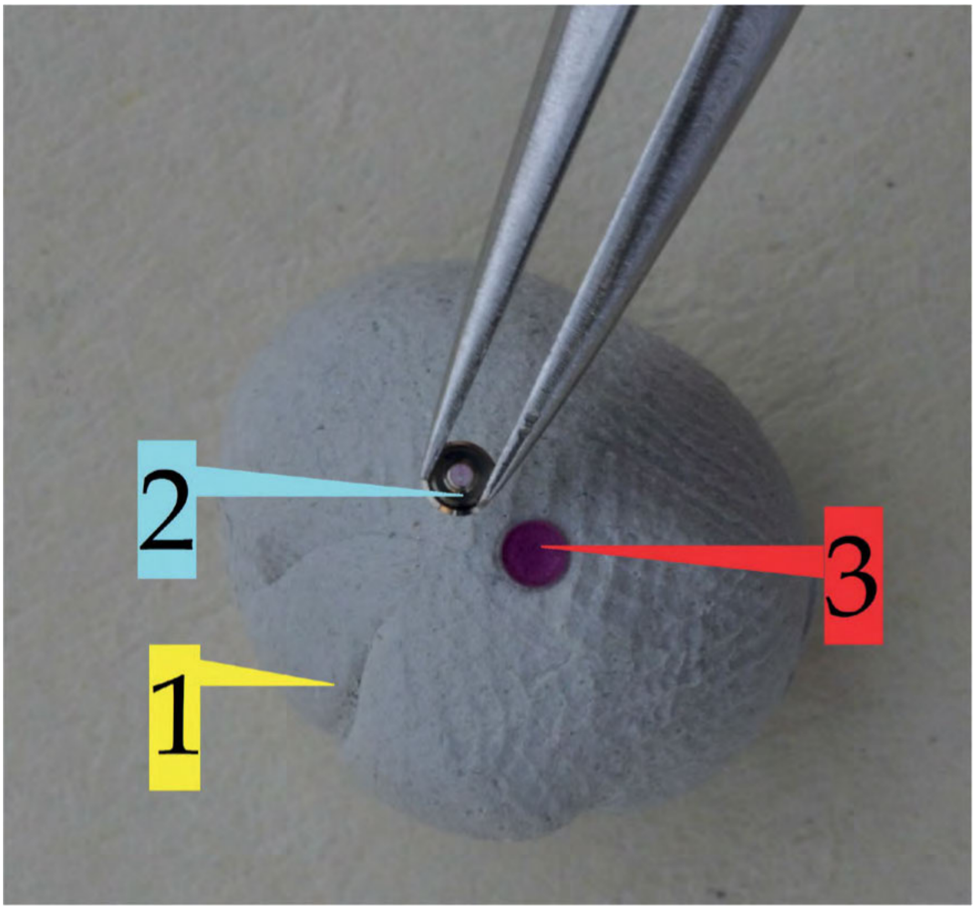


Fig. 221: Showing the separated end stone (3).

OILING THE INCABLOC

This is probably one of the hardest jobs to get right, taking plenty of practice, but don’t get too stressed as you will get there in the end! If you feel this is beyond you there are two other options.

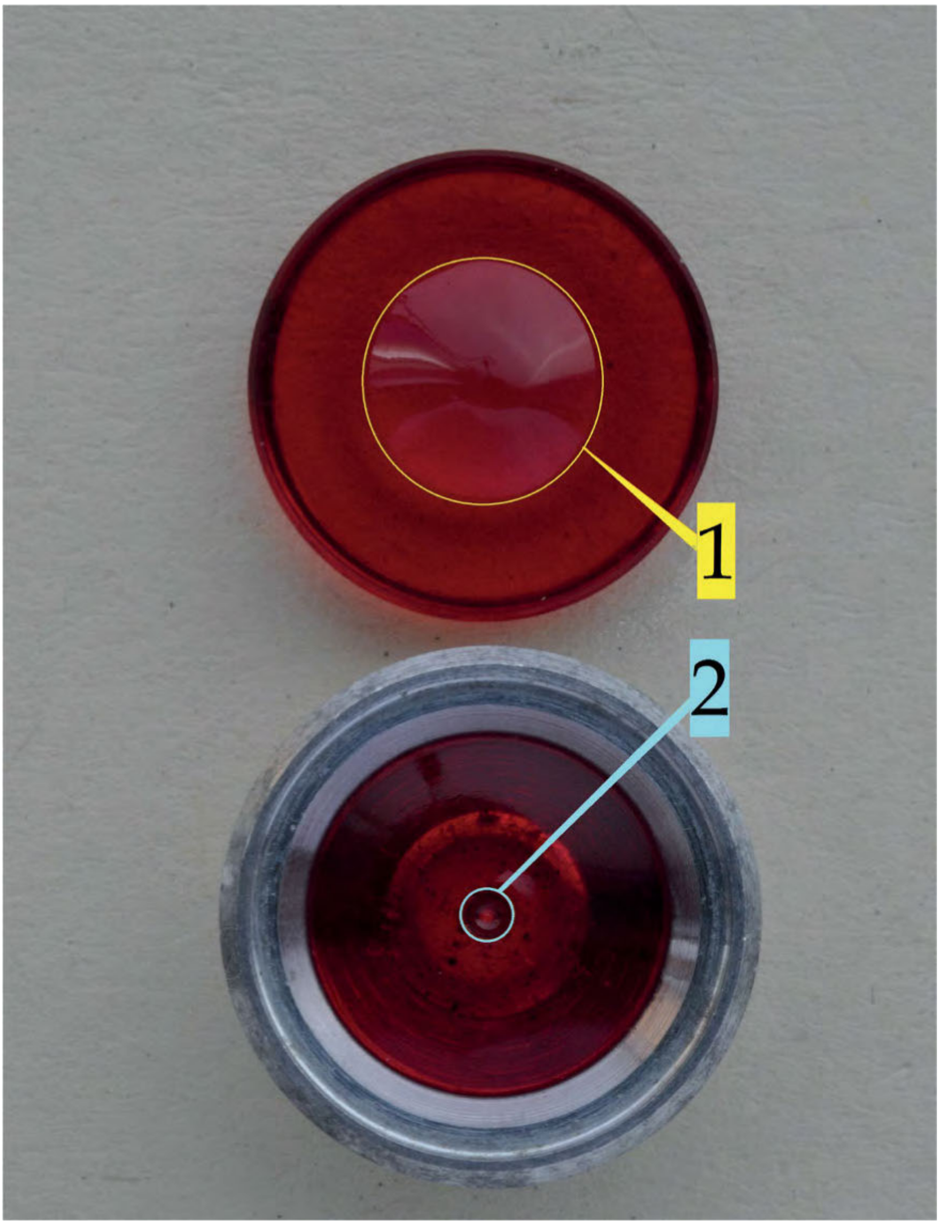


Fig. 222: The correct amount of oil applied to the end stone (1) and jewel in the chaton (2).

Method One

The most practised method is to hold the end stone between a pair of tweezers. Best practice is to use brass tweezers, so as not to chip the jewel, as brass is softer. Personally, I have always used carbon steel tweezers and have never damaged an end stone using them. Your end stone should be flat on the bench, held on the sides with the tweezers of your choice, so that the flat surface of the end stone is facing you. Take the smallest oiler you have and add a drop of oil on to the centre of the end stone so that the oil nearly fills between 50–70 per cent of its surface area. Using the oil left on the oiler, dip in the jewel hole of the chaton (you only need a very small amount of oil here). I must stress that the droplet of oil on the end stone must be a perfect droplet, or the oil will spread in a day or two and all your hard work will be wasted. If your droplet of oil isn't quite covering half the surface area you can apply more to the end stone.

Method Two

Hold the chaton between your tweezers. The difference here is that you have the inside of the jewel showing. Take an oiler charged with Moebius 9010, and apply the blob of oil to the hole in the setting. A small amount will go down the hole and the rest will circle the hole (this must be a smear-free circle only).

Roll the chaton over, pick it up by its stepped sides, and dock it with the end stone. Roll the two over quickly with the tips of your tweezers (hopefully they will stay together, because at this point the oil is not providing any adhesion).Whether you have Incabloc or Kif, fit both oiled chatons back into the watch's balance cock or main plate, and refit whichever spring type belonging to the shock setting you have.

Once both are fitted you will have to give the movement a vigorous shake up and down so that the oil will be transferred to the end stones.

The major disadvantage to this method is that you only oil about 40 per cent of the surface. This is better than nothing, butit should really only be done in desperation.

Method Three

Read the section on automatic oilers at the end of the previous chapter.

Note: Oiling the Kif is exactly the same as oiling the Incabloc. Only fitting the spring is different.

Docking the oiled end stone with the chaton Kif or Incabloc

To reset the end stone in the chaton, turn it over so that the back of the chaton is facing you. Pick it up by its stepped sides and place the chaton over the end stone. Mate the two together, making sure not to smudge any of the oil as you do so. The oil should hold the end stone and chaton as one. Turn the setting over using only the tips of your tweezers to roll it over. If you have smudged the oil you will have to start again. Unfortunately there are no shortcuts here!

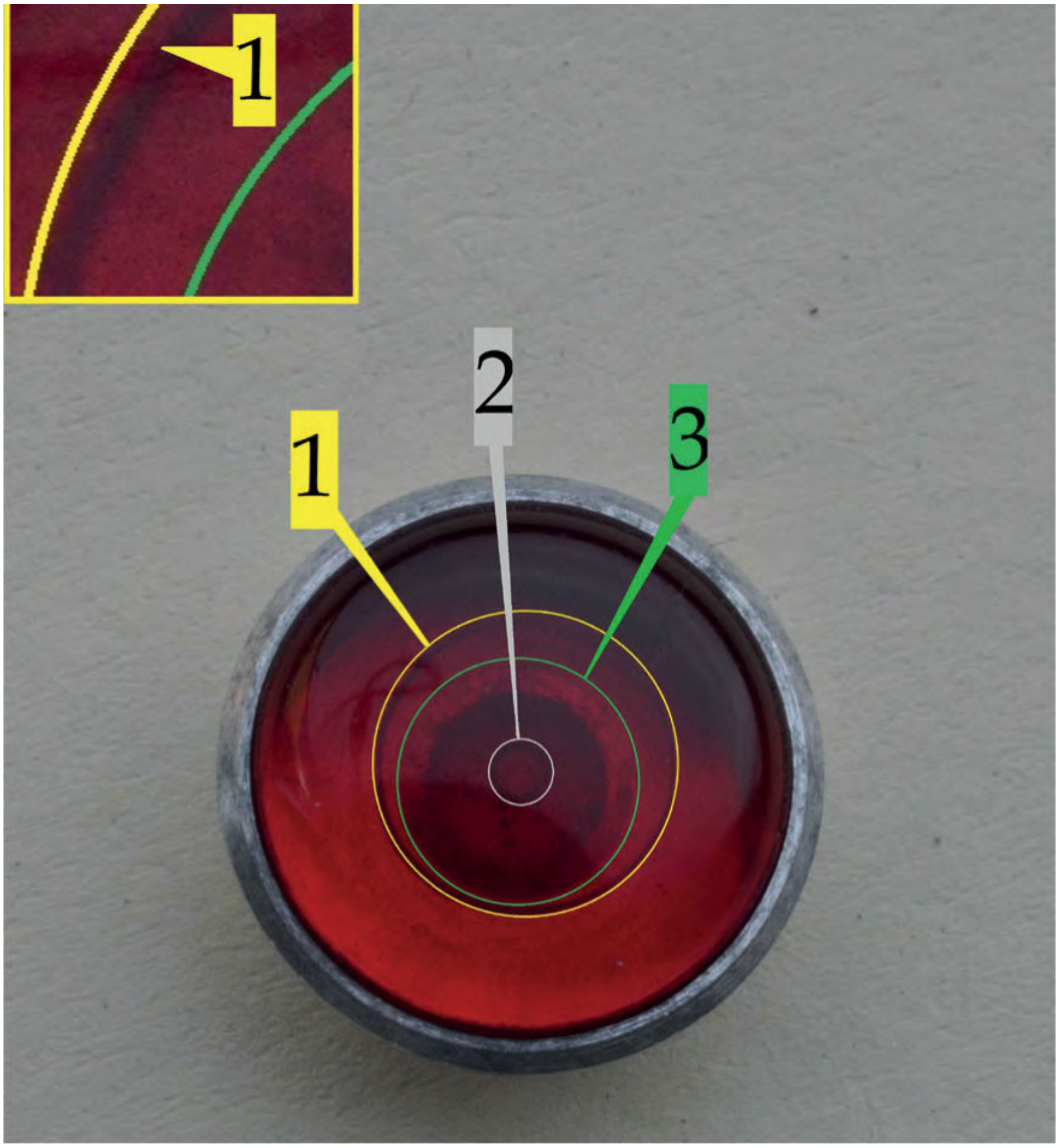


Fig. 223: You should be able to see the ring of oil (1) through the end stone. Don't confuse the ring with the oil sink of the chaton jewel (3) or the pivot hole (2).

Tip: Once the stone is set in the chaton, use your tweezers just short of the tips to pick it up. If you were to hold it with the tips of your tweezers, there is a high risk of the chaton flying away.
Tip: Try looking directly above the end stone when you are docking the chaton with it, as this will help prevent you from smudging the oil on the end stone.

How to check your oiled end stone

Lift the chaton and freshly oiled end stone up to the light and look into the end stone at a slight angle. You should be able to see the ring of oil you have just applied. If you have the correct amount it should be the second larger, fainter ring of the two. The second smaller ring is the oil sink of the jewel fitted in the chaton (you may need a stronger eyeglass for this).

Tip: When you were oiling the end stones you may have noticed that one of them was thicker or slightly darker in colour. If so, the thicker end stone resides in the balance cock. Not all watches have different size end stones, but the reason for a thinner end stone in the base plate is simply that there is less room between the Incabloc and the back of the dial for the end stone to move if it receives a shock.

Refitting the chaton in an Incabloc

First open the Incabloc spring (a good time to use the Rodico to hold it open), as it should have been closed during the cleaning process. Place the cleaned and oiled chaton with the fitted end stone in the setting of the watch. Make sure the balance pivot is located in the chaton's jewel hole. You can do this by looking though the top of the end stone, and looking at the end of the pivot in the hole. Next, carefully bring down the retaining spring and lock it into place. This is done by gently pulling back each one of the tips at a time, just so you can locate each end in the securing groove that they clip into. The other chaton/end stone is fitted in exactly the same manner on the other side. Do take care as the Incabloc springs are easily broken or bent. You will only break one once!

Tip: When you hinge back the Incabloc spring, take care because with some models there is a small chance that the spring will drop out of its setting. To avoid this, a small ball of Rodico just behind the setting will stop the spring hingeing back too far.

REFITTING A KIF SPRING

Drop the chaton and fitted end stone into the setting (if you have a thick end stone, this still goes in the balance cock in a Kif or any other type of shock setting). Pick up the Kif spring using a piece of Rodico. Remember to pick it up by one of the spring corners, so that it can be easily deposited on top of the setting in the watch. Once over the setting, use the tips of your tweezers to release it from the Rodico. Locate one of the spring's tabs into the groove that the spring fits into. Make sure one of the other tabs is in line with the cut-out in the setting.

Using your Kif tool of choice (homemade or factory), push lightly down on the spring and slowly rotate it. Watch with an eyeglass and you should see the tab located in the settings cut-out disappear into the locking groove. Keep turning until the third tab is located into the locking groove – and the job is done.

33. ADJUSTING [AND REGULATING] A BALANCE SPRING

ADJUSTING A BALANCE SPRING

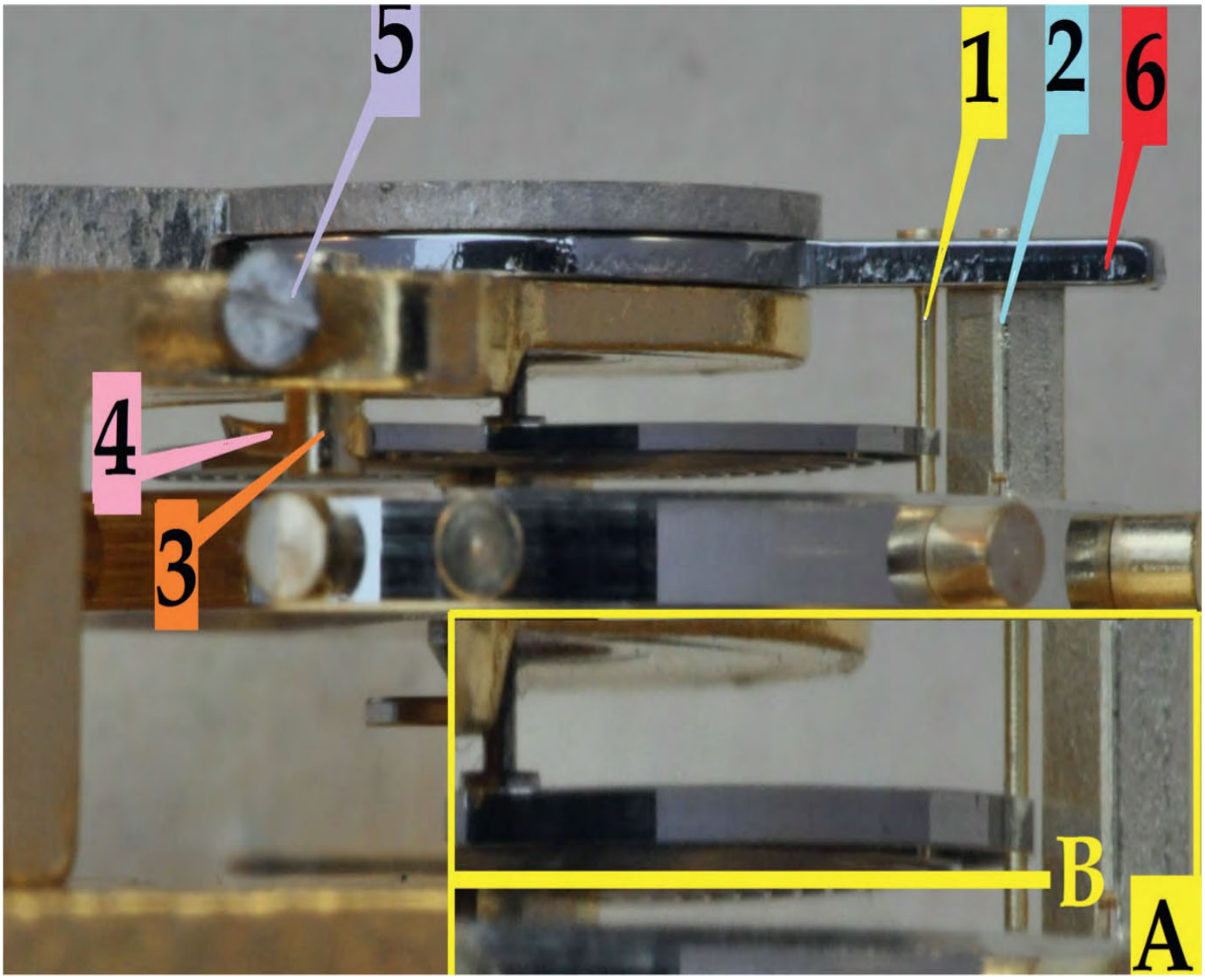


Fig. 225: 1. Index pin (or curb pin). 2. Boot or this maybe a second index pin on some watches. 3. Stud. 4. Taper pin. 5. Stud screw. 6. Index image: (A) shows the flatness of the spring highlighted by line (B).

It’s quite common to find that a watch’s balance spring will require some type of adjustment after cleaning. Balance springs are very delicate things and are easily disturbed from their original factory setting. This can’t be avoided, especially when it comes to the older blue-type springs, and even more so when they’re over-coiled. The spring will probably need only the lightest of touches with a pair of tweezers to adjust it to the required position. If you are working on a watch with no shock-resistant bearings, and you’ve rightly removed the balance and spring from the balance cock, this will instantly mean that you have lost the original height of the spring. The stud will never return to its original position when reuniting the balance and its spring to that of the balance cock.

The height of the balance spring is probably the most common adjustment you will have to make to a watch with an adjustable stud. To identify this you will have to view the balance from its side and look at the spring’s most outer coil, looking into its most centre coil. Correctly adjusted coils should all appear to be of the same level and the same height from the balance wheel. If you look directly at the side of the spring, all the coils should be hidden behind each other.

Stud Too High

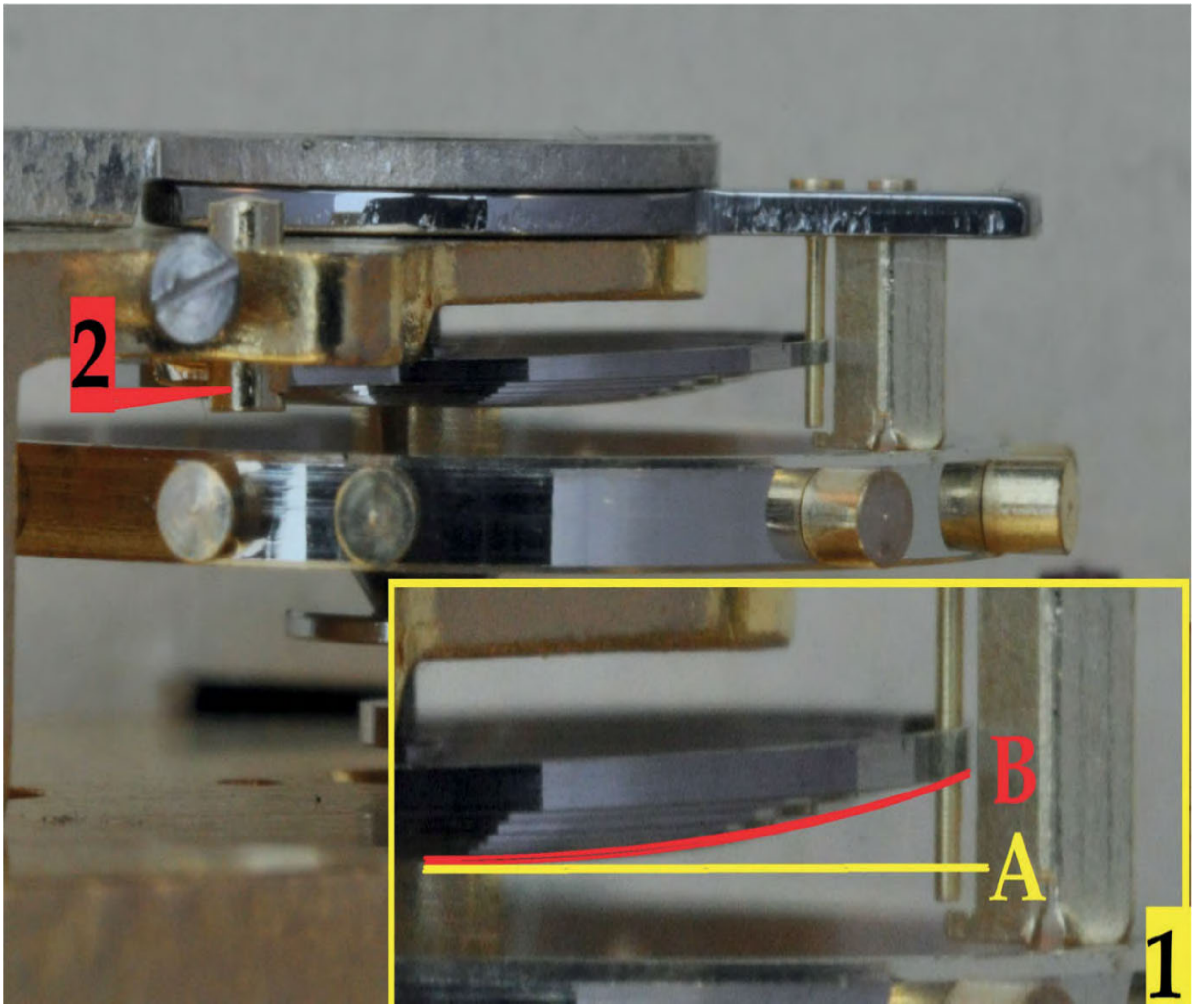
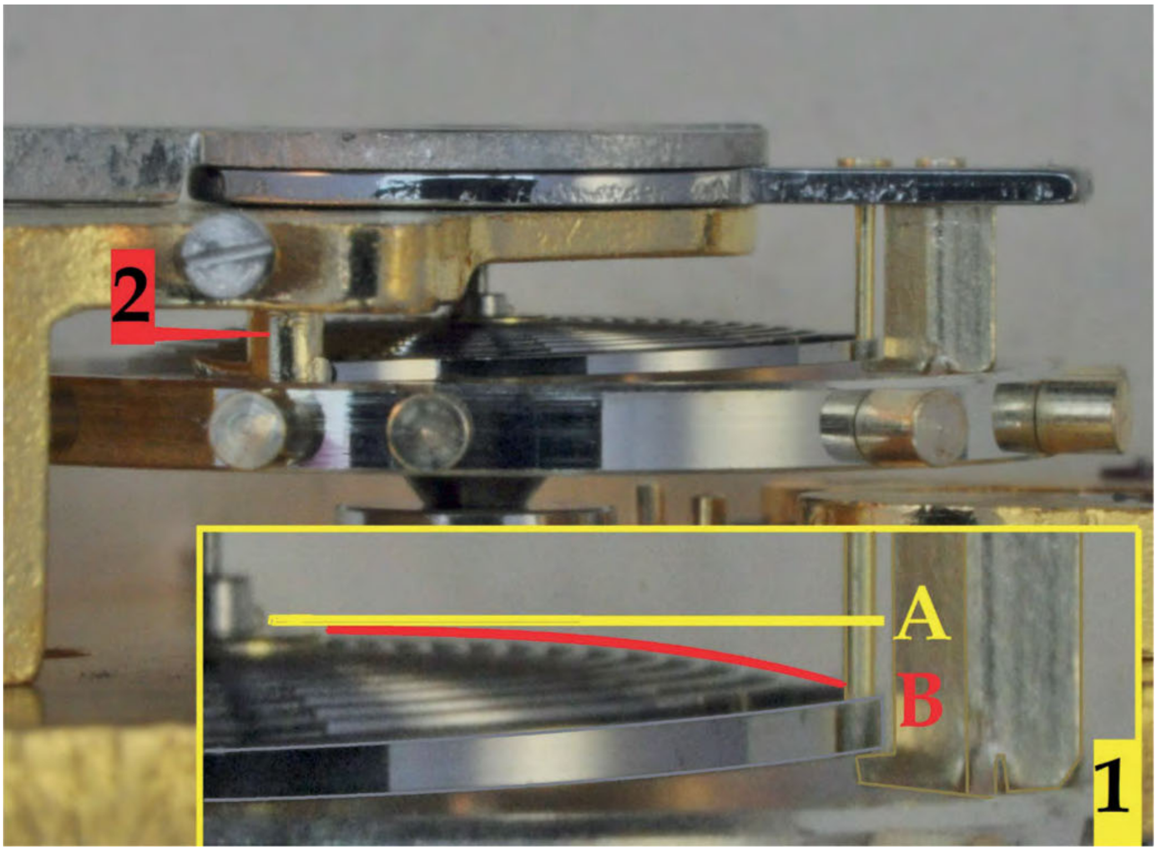


Fig. 226: (1) Clearly showing that the spring's stud (2) is set too high, causing the spring to curve upwards (highlighted by line B). Line (A) clearly shows where the spring should be.

If the stud is too high, each of the coils will be slightly higher than its neighbour, giving the spring a dished appearance. The most common side effect of this is that the very outermost coils of the spring will be either rubbing on the underside of the centre wheel or on the underside of the balance cock. This will impede the amplitude of the balance's wheel, or will bring the watch to a complete stop when the watch is turned dial-side up. This will also have the effect of the balance spring trying to lift up the weight of the balance wheel, meaning that there will be a loss of energy, also resulting in a loss of amplitude.

Adjustment: Loosen the stud screw no more than a quarter of a turn, so that it will maintain some grip on the stud, making it easier to adjust. Lower the balance spring by pushing on the top of the stud with very, very light pressure, using the tips of your tweezers until you bring the spring level. Tighten up the stud's screw.

Tip: When loosening the stud screw, it is always a good idea to angle your screwdriver slightly upwards. If its blade slips out of the screw's slot, this will prevent harm occurring to the spring. A rogue screwdriver can leave devastation beyond repair. If you angle the screwdriver by only two or three degrees and it slips, its blade would ride over the balance assembly and not into the balance itself, saving you that heart attack moment!



Stud Too Low

Fig. 227: (1) Clearly showing that the spring's stud (2) is set too low, causing the spring to curve downwards (highlighted by line B). The line (A) shows where the spring should be.

If the stud is too low, the spring will have the appearance of dishing downwards. In the worst cases, the outermost coils of the balance spring will be rubbing on the balance wheel's arms, causing one of two things: it will either slow down the amplitude of the balance wheel, or bring the watch to a complete stop. If the spring is even very slightly out of flat, this will lower the amplitude of the balance, as the spring will be bearing down on the balance wheel. This means that there will be more pressure exerted on the balance wheel's bottom pivot, which will also result in increased wear.

Adjustment: Loosen the stud screw by a quarter of a turn, using a screwdriver. Use the tips of your tweezers to raise the balance spring by pushing on the bottom of the stud until the balance spring looks level. *PLEASE remember to use only very light pressure!*

Once the spring looks level, tighten up the stud screw.

A Skew Balance Spring

This is probably one of the trickier adjustments, as a heavy hand can trash a balance spring beyond repair. If the spring is dipping up or down away from the index, this is normally caused by either the balance spring being bent/twisted in the stud, or the index area of the spring's outermost coil. The stud itself may be residing in its hole at a very slight angle. It is best to try and see if the balance spring stud has any movement in its hole first, to bring the spring into level.

Adjustment: Using just the very tips of your tweezers, apply very slight pressure to the top or underside of the spring (depending on which direction you wish to level it). Make sure you place them as close to where the spring enters the stud as you can get. Push up or down on the spring to bring it level.

ADJUSTING AN OFF-CENTRE BALANCE SPRING

The basic geometry of an average spring should be as follows: locate the balance spring at rest (with the mainspring wound down). Look directly down at the spring: it should be sitting centrally in the balance wheel. Think of it like this: if you took a set of compasses and drew a circle around the balance spring, using the balance pivot hole as the rotation point, the spring should be sitting centrally in this circle.

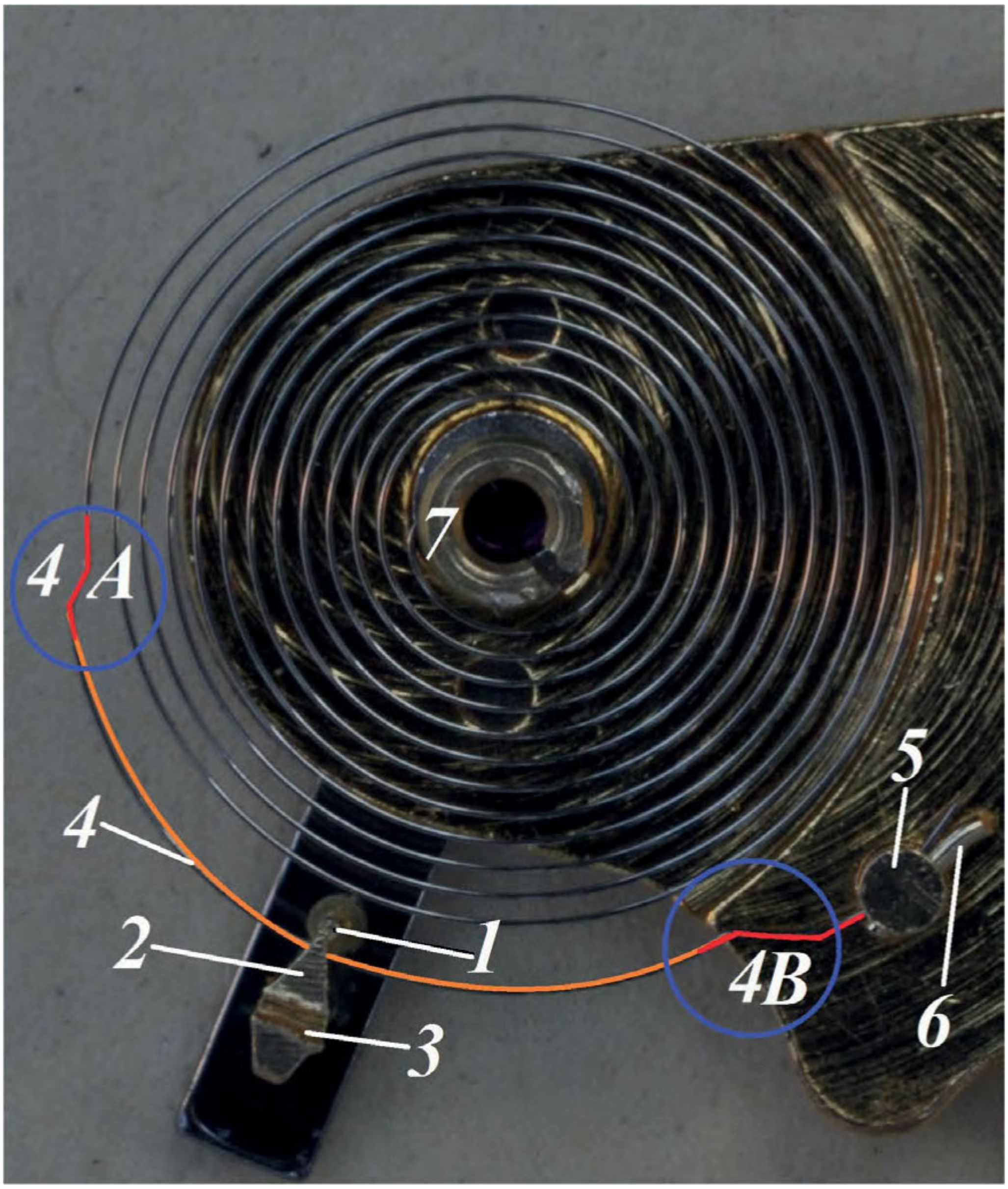


Fig. 228: (1) Curb pin. (2) Boot or second curb pin. (3) Screwdriver slot. (4) Golden curve. (4A) Z bend. (4B) Z bend. (5) Stud. (6) Taper pin. (7) Collet.

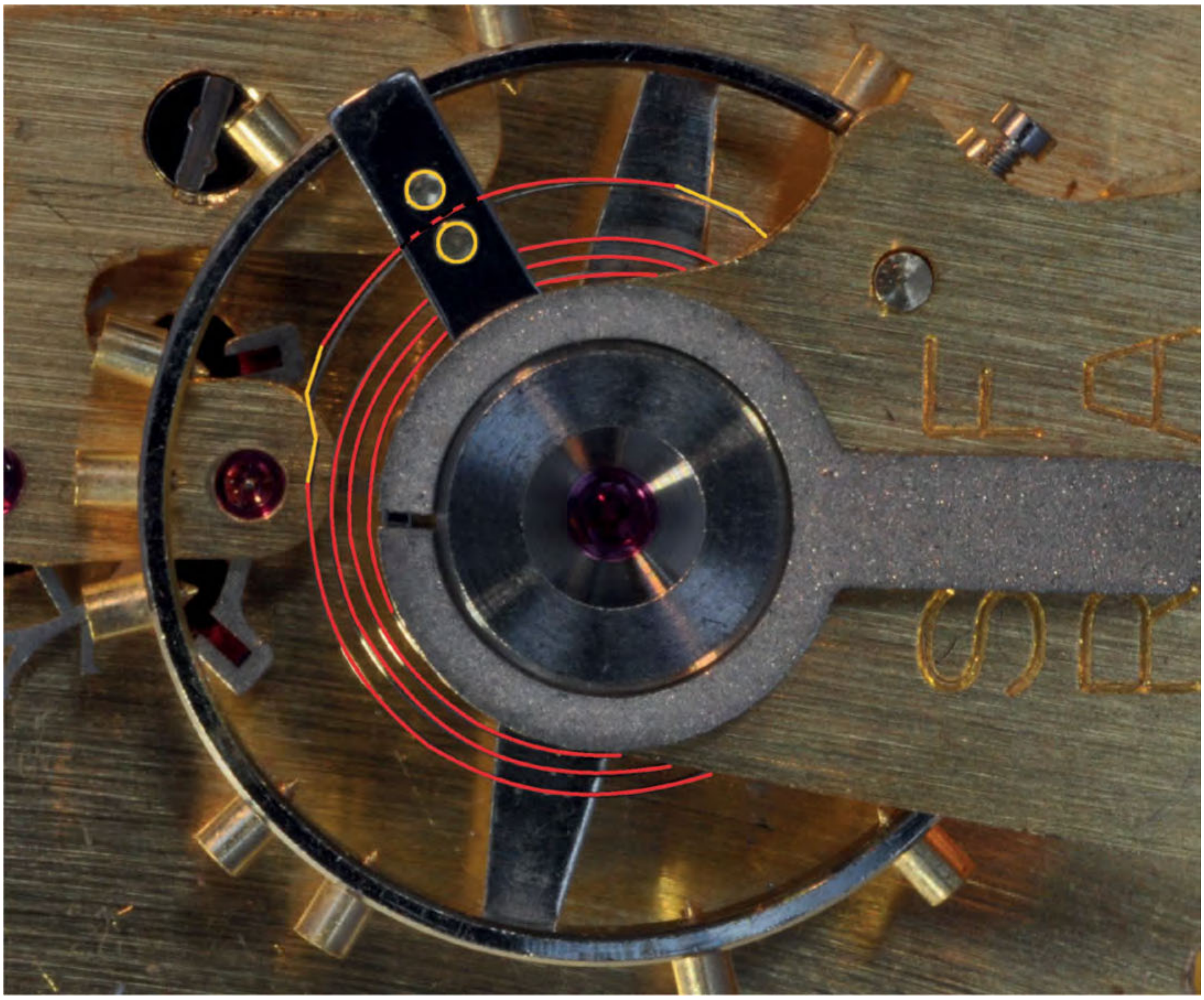


Fig. 229: A centred balance spring. The Z bends and the balance spring resting in between the two index pins can be clearly seen.

A typical balance spring should be shaped so that the last 180 degrees of the spring's last coil (see Fig. 228 (4)) will be bent outwards with a 'Z'- shaped bend (Fig. 228 (4A)).The coil should be twice the distance from its neighbouring coil, compared to that of the other coils. This extra distance is to provide clearance for the index, so that the neighbouring inner coil doesn't tap the back of the index pin. This would cause the watch to run fast, or create poor amplitude, as energy is lost when it collides with the back of the index pins.

Note: Ideally the amplitude of the balance (its swing left or right of the zero line) should be between 270 and 310 degrees.

Continuing around the spring anticlockwise, just as the balance spring enters the stud (6), there will be a second ‘Z’-shaped bend (4B).This shape provides clearance for the second coil of the balance spring as it expands and contracts during oscillation, so it doesn’t collide with the stud (6). If it did collide with the stud (6), the natural harmonic of the balance spring would be affected, causing poor time-keeping or low amplitude.

This is certainly one of the hardest adjustments to teach anyone. Some people just seem to be naturals at seeing and adjusting an out-of-centred spring, while others really struggle with the task, normally resulting in making the spring worse. A jobbing watch repairer should be able to adjust this error by bending the spring’s outer coil in situ to re-centralize it. To achieve this correctly, any adjustment is only ever made to the outer coil of the balance spring.

This is normally done by manipulating the ‘Z’-shaped bends. This will allow the spring to move up/down, left/right by smoothing it out or making it more dramatic. No adjustment should ever be made to the curve between the two bends. I will refer to this as the *golden curve*, because this is where regulation takes place. This part of the spring has been formed into a perfect semicircle, so that the spring will reside perfectly between the two index pins, no matter where the index is moved to. As the balance spring expands and contracts, it will tap the outermost pin on expansion and the inner one when the spring contracts.

The following series of pictures show four typical types of balance spring bends. Two of them have been bent around the stud area, and the other two around the second ‘Z’ bend. Looking at the first picture, this spring has been bent towards the centre of the balance wheel, causing the coils of the spring to move off centre. You can see this in the distance of the coils diagonally opposite the stud. The distance between them has increased (nearly doubled). If you look towards the opposite side of the balance spring you will see that the distance of the coils has decreased. In the second picture you will see that the opposite applies, in that the balance spring has bunched up towards the stud.

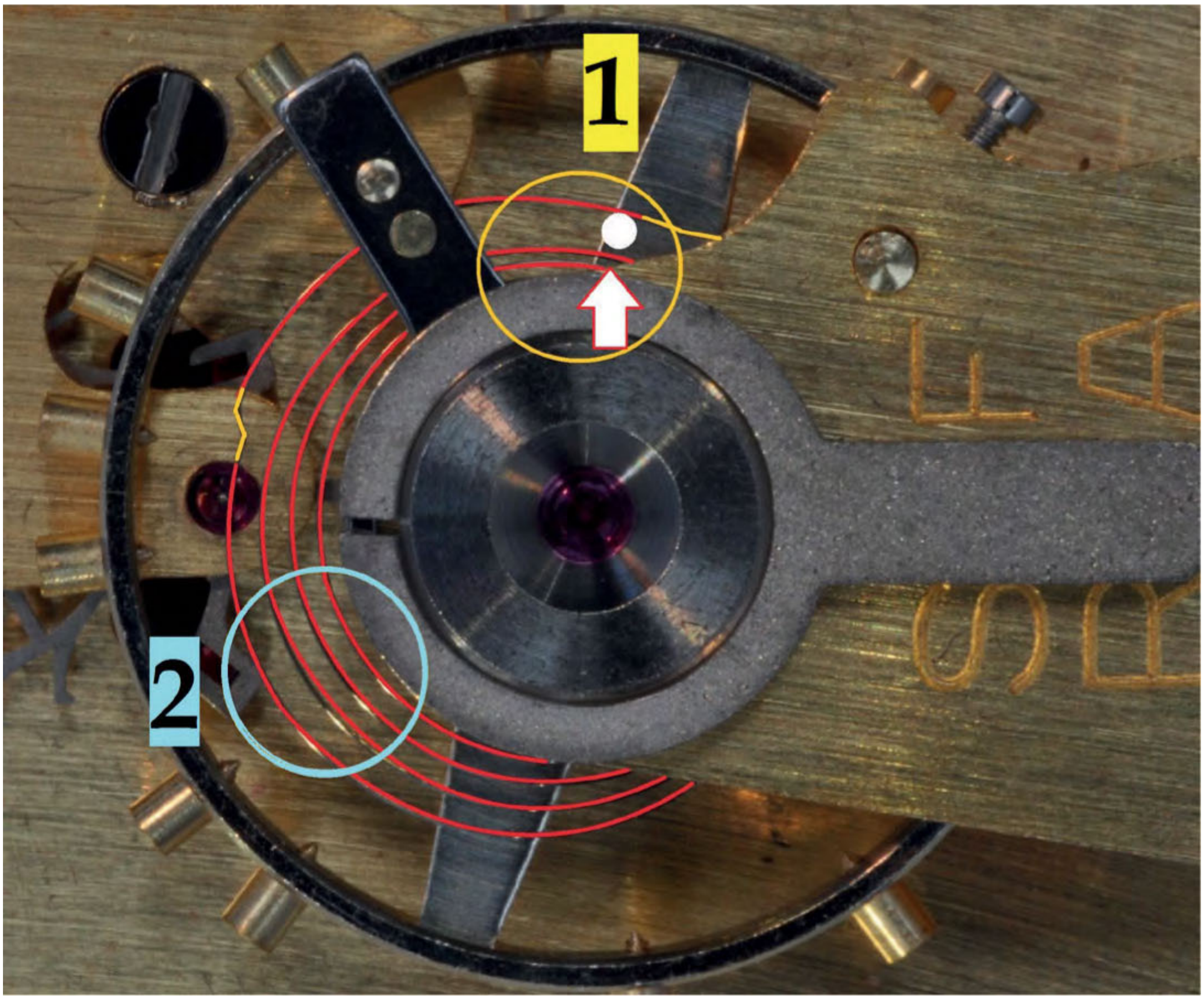


Fig. 230: An off-centred balance spring. (2) The coils of the spring are wider at this point. (1) Where to put your tweezers to bring the spring back to centre.

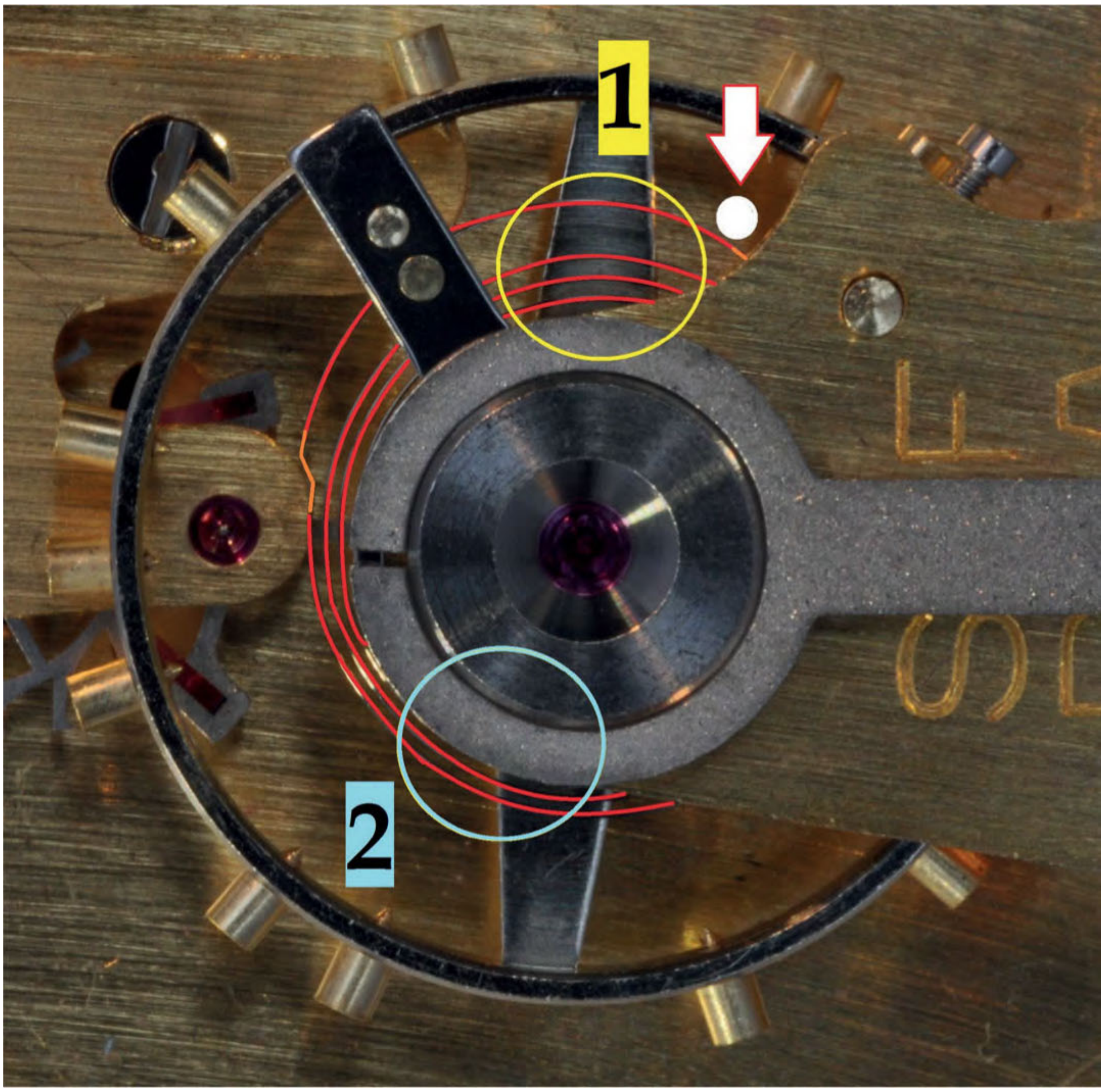


Fig. 231: This spring has the coils pushed towards the stud. In (2), the coils of the spring are bunched tightly. (1) Where to put your tweezers, and the direction in which to push.

Tools: You will need some fine tweezers (No. 3 or No. 5, the latter being the finer pair), depending on the size of watch you are working on. No. 5s are normally used for wristwatches smaller than 3cm, and No. 3s would be used on anything larger.

To adjust Fig. 230: Using just the tips of your tweezers from directly above, place them between the first and second coil of the balance spring (where the *white dot* is in the picture); you must keep your tweezers as close to the stud as you can. Push the outer coil of the spring *away* from the centre of the balance wheel, pulling the coils of the spring back in to the centre position. This in itself isn't enough to bring the spring back to its central position permanently, so you must continue pushing the spring outwards about an extra 0.5mm, no more that. 1mm will have the effect of bending the spring ever so slightly.

Tip: Don't be tempted to grip the spring between the tips of your tweezers, as this will damage the spring beyond your ability to rectify.

To adjust Fig. 231: Using just the tips of your tweezers, approach this time from the side, where the *white dot* is on the picture, keeping the tweezer tips as close to the stud as you can. Slowly push the outer coil of thespring in *towards* the centre of the balance wheel, so as to bring the spring back to its centre position. This in itself isn't enough to bring the spring back to position permanently, so you will have to push the spring an extra 0.5mm, no more that; 1mm will have the effect of very slightly bending the spring.

The goal is to manipulate the spring so that the golden curve is positioned centrally; thus if you move the index left or right the overall shape of the spring should remain in the centre and not be shoved in the direction that the index is moved. Secondly, when the balance wheel oscillates, the spring will tap the curb pins as the spring expands and contracts: this action is called 'breathing' of the balance spring.

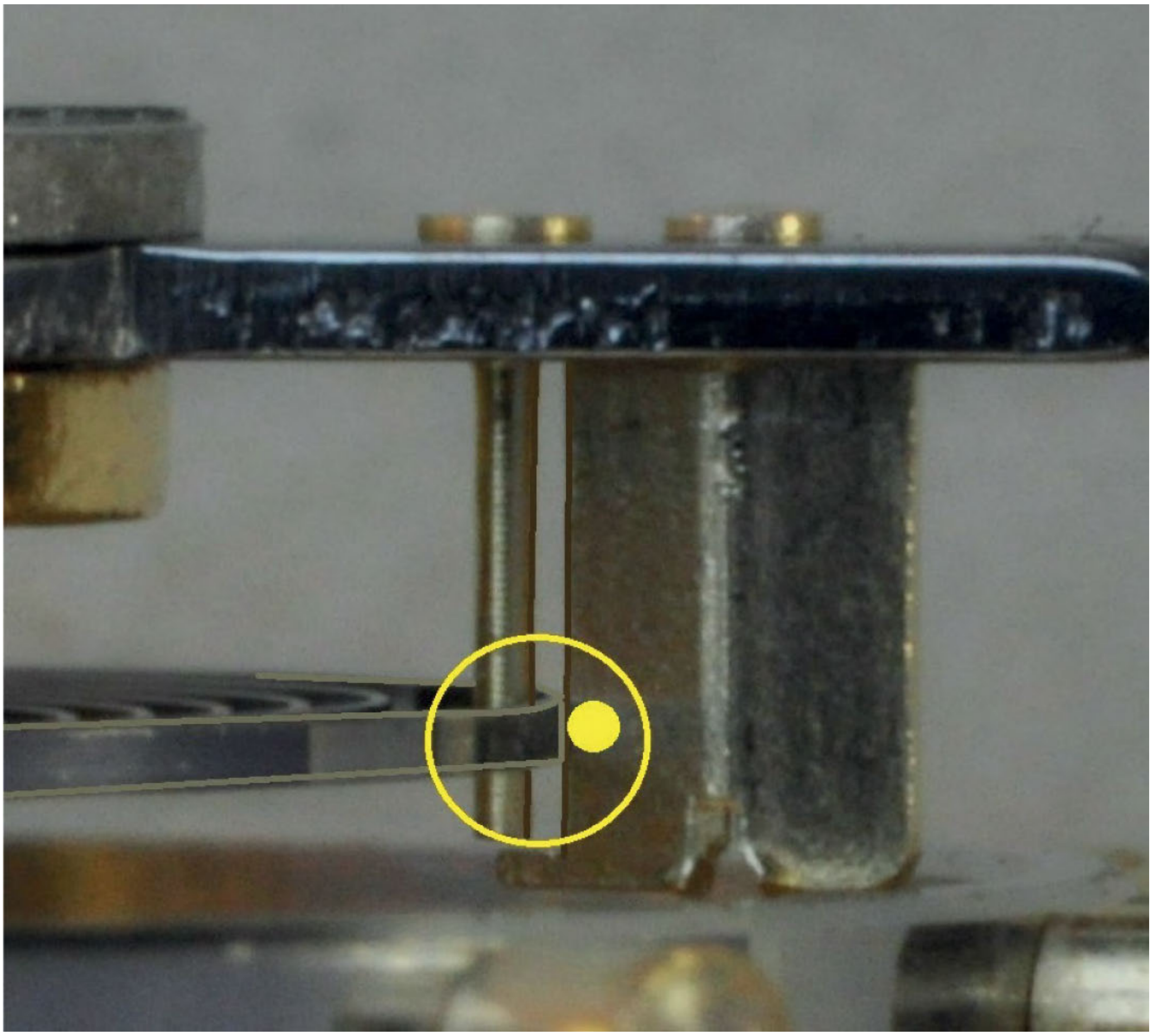


Fig. 232: A breathing spring. The balance spring is opened outwards and the spring is touching the boot (indicated by the yellow dot).

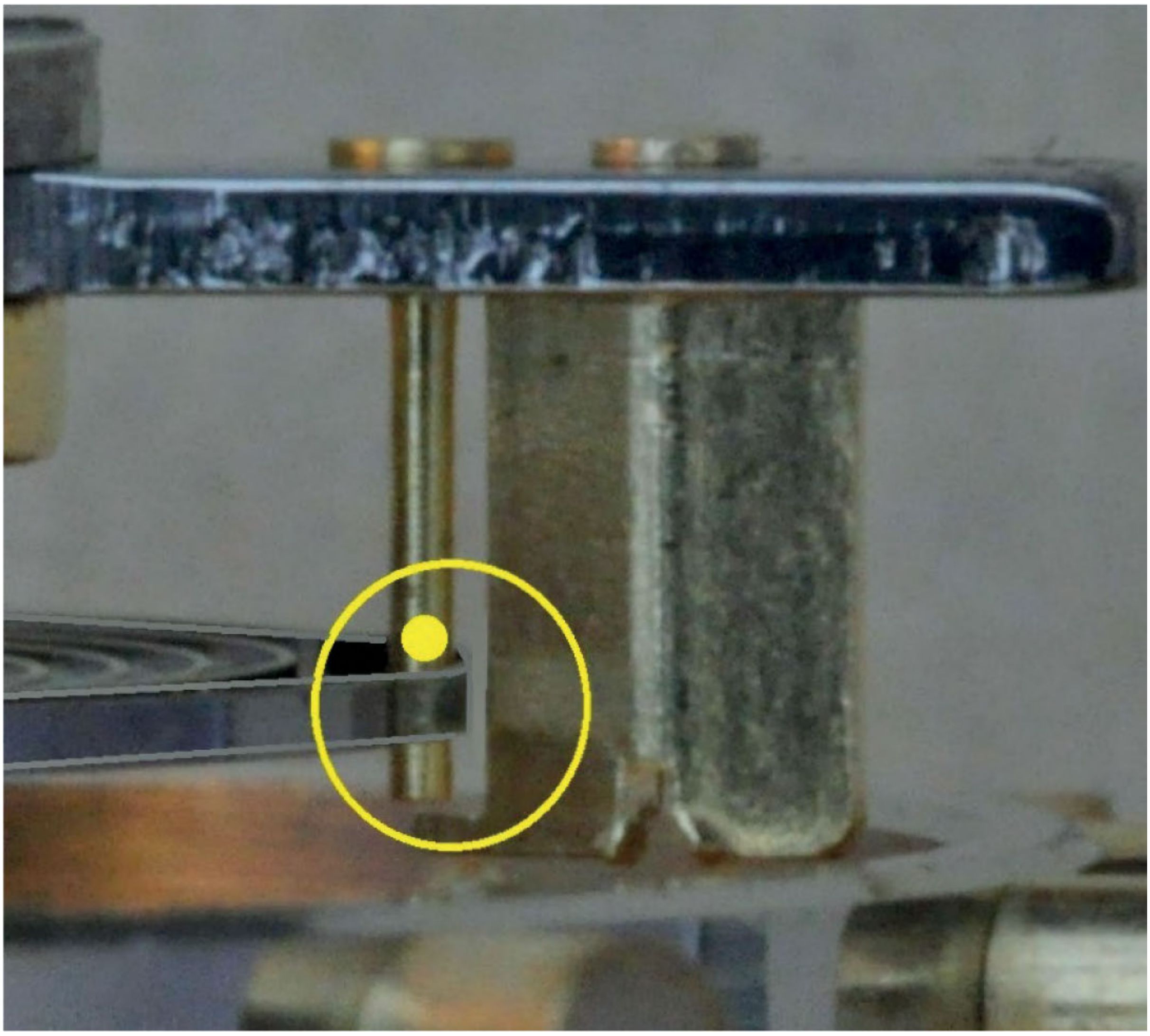


Fig. 233: A breathing spring. The balance spring is wound inwards and the spring is touching the index pin (indicated by the yellow dot).

Laws of the Curb Pins or Regulating Pins

The distance of the pins should be set at twice the thickness of the balance spring (ideally slightly closer).The closer the pins are set to each other, the faster the watch will run. The wider they are apart the more slowly the watch will run.

When the balance oscillates, the balance spring should 'breathe', meaning that the balance spring should bounce from one curb pin to the other. If the spring were to favour one of the curb pins, this will cause a gaining rate when the watch is running on low power.

In time you will find that the curb pins have been poorly adjusted, or they may have moved position during the cleaning process. It may be necessary to adjust them so that they are parallel to each other. If you find that the index pins aren't parallel, this would have an effect on the effective length of the balance spring, caused when the watch is turned dial up or dial down. This would change the position of the balance wheel. The result would be that the balance spring's height in the curb pin would also change. If the curb pins weren't parallel, the distance that the spring is breathing would also change, causing the watch to lose or gain in rateable time.

To adjust the pins, a very fine pair of tweezers is normally used – the likes of No. 5s are best.

Now that the balance spring is correctly adjusted, the next job is regulation of the watch, and this can only be accurately accomplished with the use of a watch repairer's timing machine.

The Etachron

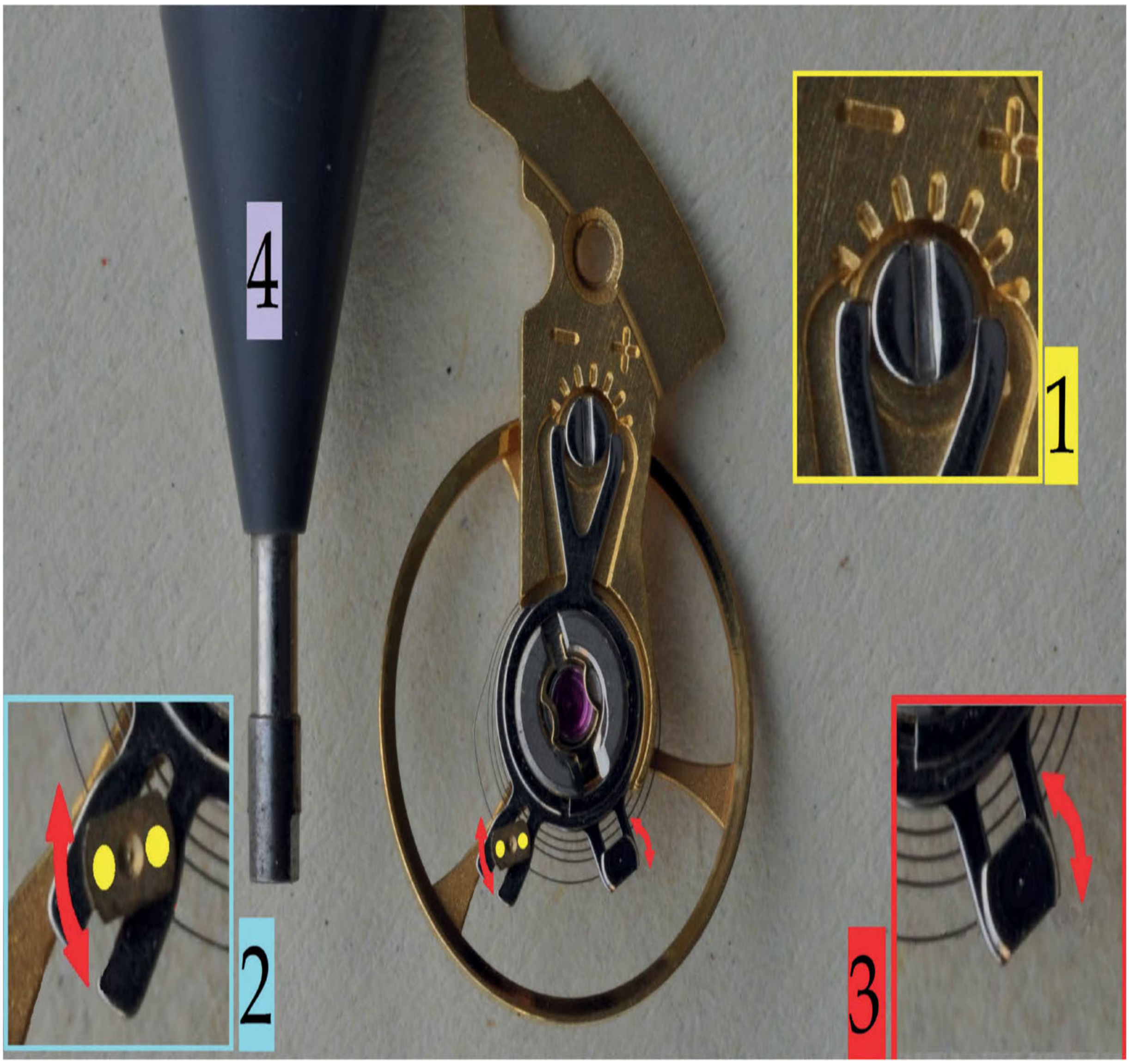


Fig. 234: Etachron. (1) Adjusting screw for the index. Move the screw one line: this represents about five seconds (it is best practice to leave this at 0 and only use it to adjust the watch by just one or two seconds. (2) Adjustable index pins. (3) Adjustable stud. (4) Tool used to adjust the stud and index pins.

This type of index has adjustable index pins (Fig. 234 (2)), which are mounted on a turntable that can be moved with a tool (Fig. 234 (4)). Using this tool, the space between the balance spring and pins can be increased or decreased without the need to bend the curb pins. To adjust the breathing, or so that the spring rests between the two curb pins when the balance is at rest, the stud can also be rotated with the same tool.

34. REGULATING A WATCH

The only really satisfactory method of regulating a watch is with the aid of a machine called a watch timer. However, these are relatively expensive, and as this is your first watch, you're probably not going to splash out large sums of money. In this case the only option you have is to run the watch for twenty-four hours, preferably setting the seconds hand as well to the exact second, then record your results the next day and adjust the watch by trial and error.

Adjustments are made using the index by moving it a minuscule amount – if you see it move by even a quarter of a millimetre, this will affect the rate of the watch by as much as 20–30sec a day. If the watch is out by 10–15sec a day, the index needs to be moved no more than 0.03mm.

Running fast: Move the index pins towards the stud, or move the tail end of the index that resides on the fatter end of the balance cock towards the 'R' (for 'retard').

Running slow: Move the index away from the stud or towards 'A' (for advance).

WATCH TIMERS

Watchmakers have been using watch timers since the dawn of electricity. These machines let you adjust the watch very quickly, and do away with the guesswork of just moving the index randomly. The machine normally comes in two parts: the microphone and the reader. The microphone is a clever bit of kit: it has an adjustable spring-loaded movement holder, in which a movement or watch case can be fitted ready for timing. It is able to swivel into any position you like, should you wish to time the watch in multiple positions.

The reader gives us a visual and diagnostic aid and helps us adjust the rate of a watch in a variety of ways. It gives us an audio aid by way of an amplifier, which means you can hear what's going on. The readout it prints can be used to identify a multitude of other faults, according to the patterns it prints out or shows on the screen.

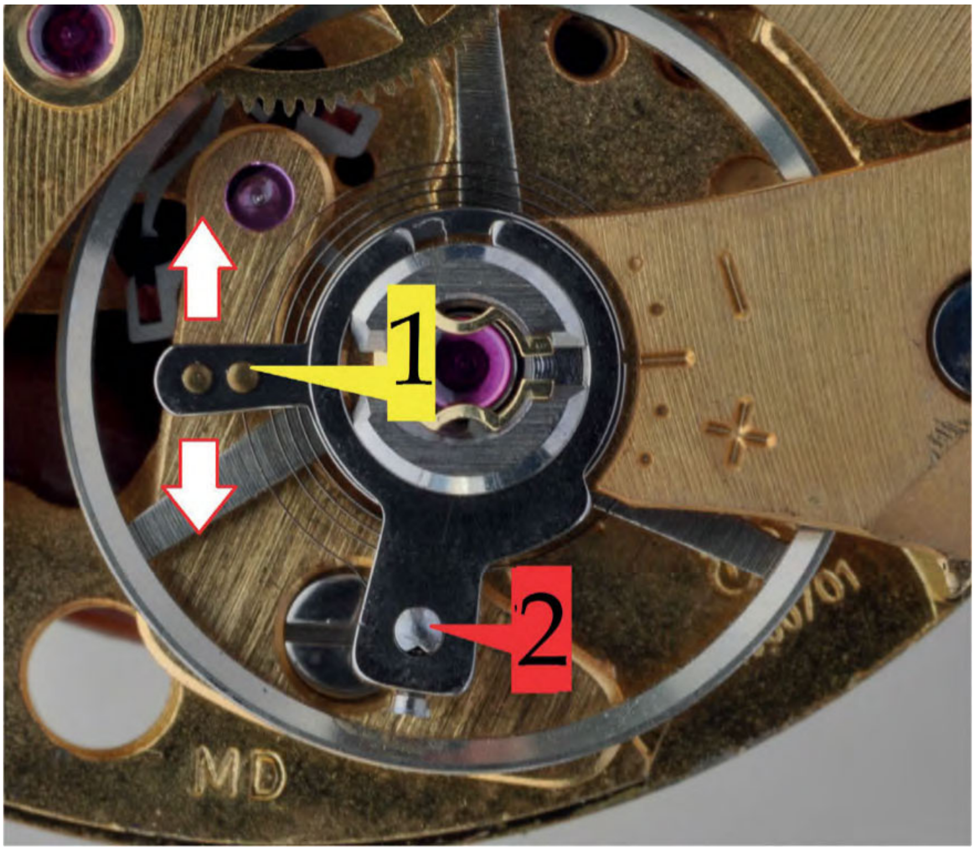


Fig. 235: Two-piece index. (1) The index. (2) The adjustable stud holder used to adjust the beat of the watch.

If you are intending on fixing a number of watches, either as a hobby or as a fledgling career, I would strongly advise you to buy one of these machines. Living without one would make any job very slow to complete, certainly with regard to regulating a watch.

The older valve machines from the 1940s are still up to the job, but instead of a digital readout like the new machines, the majority of these older ones print out a tickertape reel of paper for you to read. The modern machine still imitates this readout, so they both give you the same basic information. If you happen to inherit or buy one of these machines, I would recommend having the electrics checked out by a certified electrician, as most of them are fairly old.

The first thing to remember when using these old machines is that they're not quite 'plug-in and play' like modern technology. The paper rolls can normally be found in till (cash register) suppliers, and the ink ribbons are the same as the old typewriters. These can be picked up on internet websites and at auctions.

The modern Swiss machines are quite expensive but are better machines by far. Most are made by Elma, Witschi or Greiner, and offer additional functions as compared to their predecessors. The only down sides of these are the price, and the fact that for a beginner they tend to be harder to use. I would only recommend getting one of these machines if you are thinking of ‘going pro’. Be *warned, as even second-hand machines command a high price.*

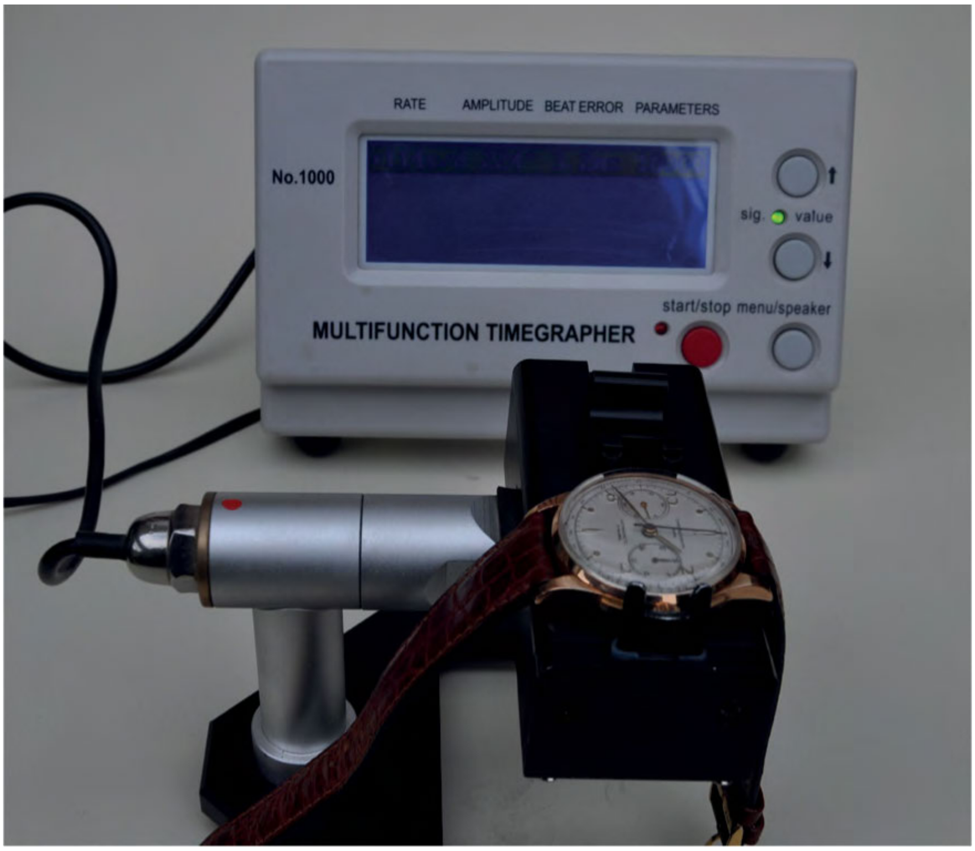


Fig. 236: Weishi watch timer.

The cheaper Chinese machine made by Weishi (not to be confused with Witschi) is an ideal machine for a beginner. These are basic but require the user to do very little, and they cost a lot less than any second-hand timer.

Tip: Make sure that the voltage of the machine is suitable for use in the country you live in (especially if you buy from the internet). Ideally you should buy from your local materials dealer.

How They Work

The microphone picks up the ticking noises generated from a watch held in it, and converts the ticking noise into an electrical signal. This in turn is displayed on a screen or on a paper printout, normally in the form of a line or a pair of lines made up of dots, running the length of the paper or across the length of the screen.

Modern watch timers (the digital type) have a built-in gradoscope as standard; this measures the amplitude of the balance wheel (the amount of rotation left and right).

The older valve-type watch timers, like the Vibrograf, had a plug-in extra which was optional. This is something you should consider if you buy an older machine, as they were very expensive when new, and only large service centres had them and second-hand ones are quite rare. Knowing the amplitude of a watch is an instant indication of how well it is working.

To read the amplitude accurately you need only give the machine the pallet lift angle parameters, and it will accurately work out the amplitude for you. The data used normally comes from the manufacturer of the watch movement you are working on. Witschi, as a watch-timer manufacturer, made a handy book which gives you train speeds and pallet lift angles, and reprinted versions can be found on Amazon and eBay. These can be worked out manually (I shall discuss these soon).

Some might ask: ‘Why do I need to know the amplitude of a watch – I can see it, can’t I?’

The answer would be that knowing the amplitude of a watch is a good indication of how well it is working, so you can tell how good your handiwork is. Furthermore, it is very useful if you’re given a watch to inspect, because knowing the amplitude will soon indicate if a watch needs servicing or not, without you even having to open the case.

As we have seen, the watch timer’s microphone is able to rotate in multiple positions (X, Y and Z axes) to simulate a watch being worn. The five most usual positions tested are with the dial facing up or down, or with the winding button pointing down to the ground, or 45 degrees left or right of this position. Thus you can monitor the amplitude of the watch, and see if the amplitude or the regulation drops off or perks up in any one position. This can help identify other problems in a watch (these are discussed later).

Trying to see the amplitude with older watches isn’t an issue, as they normally have two crossings (or spokes) on the balance wheel, which makes it relatively easy to look at the amplitude (swing). Unfortunately this is not the case with modern fast-beating watches with their three or four crossings, as this makes the balance wheel look like a blur.

Using the Watch Timer

If you have instructions for your machine I would obviously suggest reading these first. Saying that, timers are relatively simple things to use. First, place the watch/movement in the jaws of the microphone. If the watch movement is cased, I would recommend positioning the case so that the winding crown is touching the fixed jaw on the microphone. This will help the sound travel into the microphone, due to the movement being slightly muffled in the case.

If you are using a valve-type machine you will have to let it warm up for 8min before you can use it. If you were to use it too quickly, it would fail to work unless you kept your finger on the 'start' button, and in this case any readings from it would be completely wrong. The best thing to do if you have one of these machines is to turn on your watch timer as soon as you pick up a pair of tweezers so that as soon as you need it, it's ready and waiting for you.

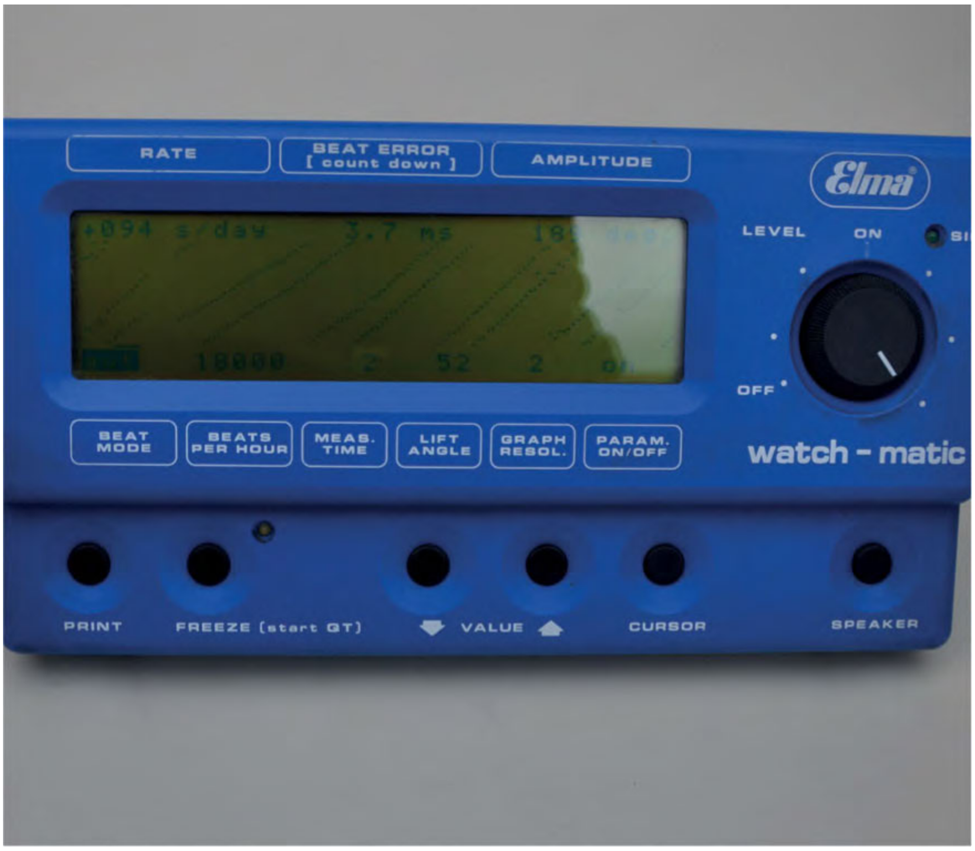
Next you will need to know the frequency (train speed) of the gear train or bpm (beats per minutes). The modern timers, if they are set to automatic, will work it out for you. The older machines normally have three to four buttons to select, and each button will work for several train speeds. As long as you press the correct button, you should have a recognizable trace with one or two lines. If you have multiple lines, try another button. Failing that, you will have to count teeth and work out the frequency. The same applies to a modern timer – if it fails to recognize the watch's beat, it will keep flashing 'Beat'. If it flashes 'Amplitude', try moving the movement around in the microphone to improve the signal, and get the timer as closer to the movement as possible.

The only advantage the old machines have over the modern ones is that they work really well with pocket watches, and you can just about get a readable trace from a Verge and a Cylinder escapement. The reading might be a little 'snowy', but you should just be able to make out a line in amongst the interference.

The modern timers quite often struggle to work with early lever escapements, and the only option is to do a train count before you clean the watch and set the machine to manual. This is why I have an old machine and a modern timer – the best of both worlds! If you have a Swiss timer you can set it to 'Frequency' and it will display a trace with an approximation of what speed the train is running at. Simply round the number up or down to the nearest thousand – for example 17,913 = 18,000.

Pallet Angle

Pallet angle is the duration of contact between the impulse pin and the pallet fork, including impulse drop and run-to-banking. It is the complete angle of contact. It is a little misleading in what the manufacturers mean, and there isn't much written about it. It is not very easy to measure the pallet angle. If you are unable to obtain the information from a book or data sheet to determine the pallet lift angle, you can set the machine to 52 degrees. This is the most common angle (normally the default angle of the machine). Keep your fingers crossed! Alternatively you can, of course, try to work it out.



Working out the Pallet Lift Angle

Fig. 237: Elma watchmatic watch timer.

This is a relatively easy job and involves using a modern digital watch timer such as an Elma or the Chinese version. Unwind or wind the watch so that the balance swings exactly 180 degrees. If the watch has a balance wheel with two crossings, you should easily be able to see how far the balance swings left to right.

If this is not the case and your balance is the more modern type with three crossings, then find yourself a laundry marker or some other fine-tipped marker pen and put a very small dot on the rim of the balance wheel. A good place is on the same side as/in line with the balance spring's stud. Do not overdo it with the marker pen, as you will be removing this mark later on.

Once you have successfully adjusted the power of the mainspring and have achieved a balance wheel arc of exactly 180 degrees, put the watch in the microphone of your watch timer. Once the display starts giving you the normal information, look at the display where it says 'Amplitude' and see if it is reading 180 degrees. If not, slowly change the pallet angle parameters on your machine, 1 degree at a time until the amplitude reading on the machine reads 180 degrees – and now the timer will give you the correct amplitude reading on your machine.

Now that the machine is set up for your watch, I can tell you what the information displayed means.

Beat

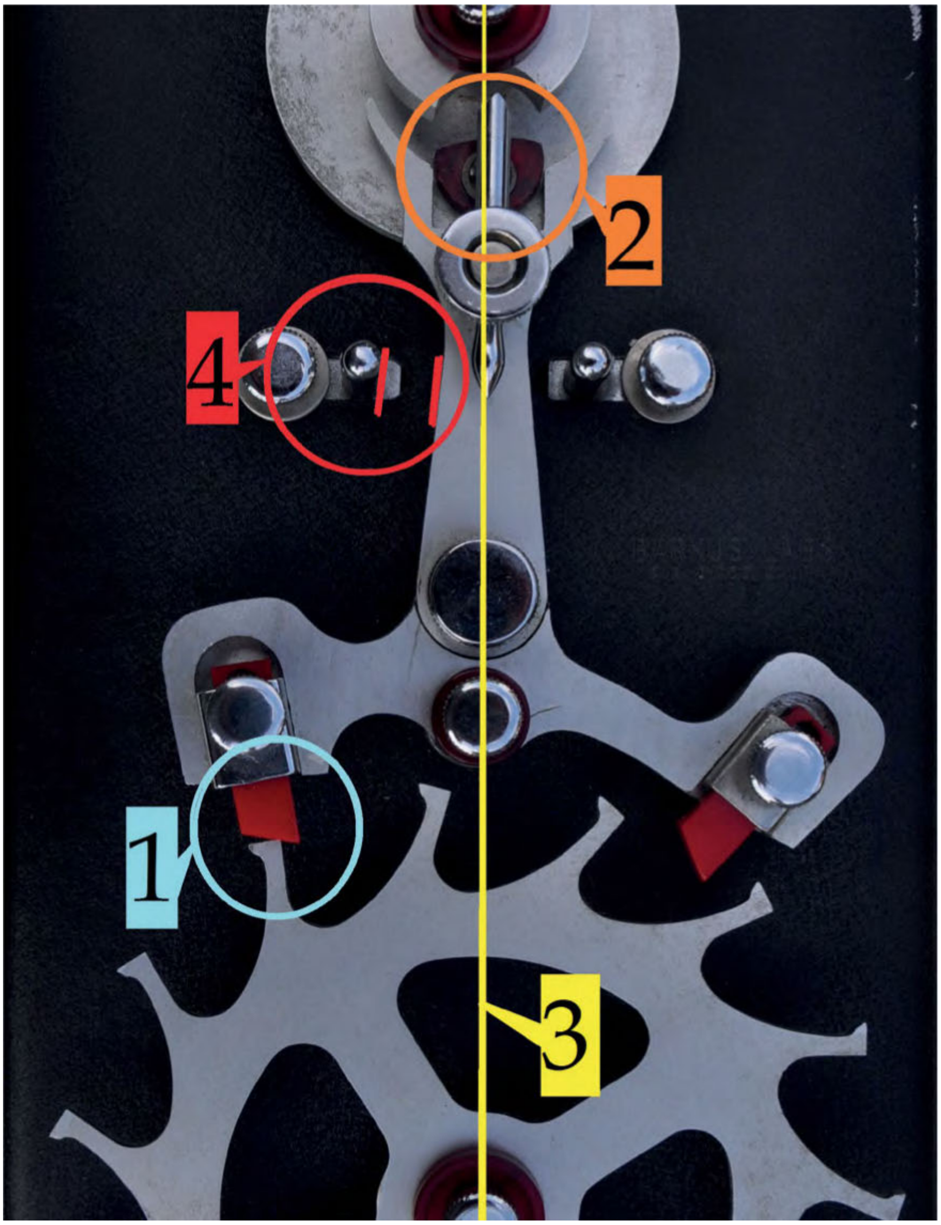


Fig. 238: An in-beat lever escapement. (1) Escape wheel tooth giving impulse to the pallet. (2) Impulse pin resting on the zero line. (3) Zero line. (4) Lever resting between the banking pins.

To understand what is meant by the word ‘beat’ you must first understand the term ‘zero line’, meaning ‘the zero line on a lever escapement’: if you were to draw an imaginary line from the escape wheel pivot, connecting this to the pallet pivot and on to the balance wheel’s pivot, this line would be the zero line. A watch is *‘in beat’* when the impulse pin of the balance wheel travels an equal distance left or right of this line as the balance oscillates. Alternatively, this is when the pallet lever (arm) rests exactly between the two banking pins when the watch is unwound, and the impulse pin would also rest on this line. If the roller were to rest either side of this line, a watch is then deemed to be *'out of beat'*. This would also be the case if the balance were to swing further in one direction than the other.

Why is it important?

With an in-beat watch, as soon the mainspring is wound, the escapement will be positioned so that the escape wheel will push on the entry or exit pallet's impulse plane. This will move the pallets, and the pallet lever will push on the impulse pin as it will be in contact with the notch of the pallets. The impulse pin will push the balance wheel, thus starting the balance wheel oscillating, and the action of the escapement will start as previously described.

A watch that is out of beat will not self-start, as the escapement will be rested in the locked position and the impulse pin would not be in contact with the pallet lever to give it a push. In this situation the watch would need something to make the balance swing, to start the watch running.

How this is displayed on a watch timer

In beat: This is shown by one continuous dotted line on the screen or printed on the paper. A digital timer will also indicate a numerical value of how in or out of beat a watch is. This will be displayed in milliseconds: for example a watch that is in beat will read between 0.0 and 0.06ms. Anything that is over 0.6ms is considered out of beat and must be adjusted.

Out of beat: This is represented by two separate lines. The more out of beat the watch, the further apart the lines will be on the graph of the machine. Again, this can also have a numerical value: the higher this number, the more out of beat the watch is. This could be displayed as 1.4, 3.7 or 9.2 – basically any number higher than 0.6 is deemed to be out of beat.

How to see if an escapement is out of beat

Before any adjustment can be made you must first determine whether it is the left or right swing of the balance wheel that is the greater.

To determine if your watch is out of beat, wind it up by one or two turns of the winder, so that only a small amount of energy is in the mainspring. If you stop the balance wheel from oscillating with a fine artist's squirrel hair paintbrush (using this will not damage the balance wheel or its pivots, whereas your fingers will), a perfectly in-beat watch will start immediately you remove the brush. An out-of-beat watch will stop left or right of the centre line – that is, the pallet's arm will not rest equidistantly between the banking pins.

Adjusting the Beat

To bring a relatively modern wristwatch back into beat is an easy adjustment due to the fact that most modern watches have what is called a two-piece index. It is much harder to adjust older watches as they tend to have a fixed stud, and adjustments can only be made by moving the pinning position of the balance spring, or moving the collet of the balance spring on the balance staff. It is important to make sure that a watch is in beat because if it is not, the balance spring will fail to bring the balance wheel back to the centre line, and will therefore not self-start when the watch is wound.

The two-piece index: The first part of this is the index, which is used for regulation. The second part is the stud holder: as the name suggests, the stud is secured to it, and this can be moved left or right to change the resting position of the balance wheel. Each can normally be moved without affecting the other.

To adjust the beat with a fixed stud

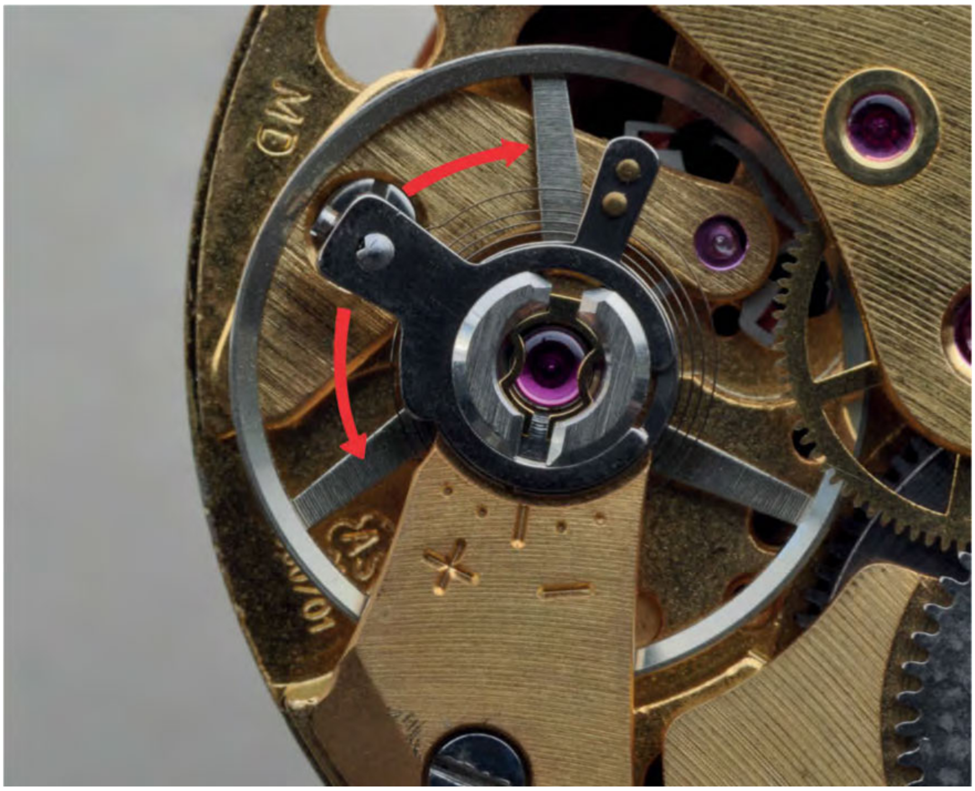


Fig. 239: Move the adjustable stud holder left or right to bring a watch into beat.

Where there is no moveable stud holder, as is commonly found on pocket watches, this adjustment is best left to a more experienced watch repairer – or just leave the watch out of beat. This is due to the fact that the balance spring's collet has to be rotated on the balance's staff, and in doing so it is very easy to damage the centre coils of the balancespring. This, in my experience, is very hard for a beginner to do and not damage the balance spring unless they have a high degree of finger dexterity.

Very briefly, to make this adjustment safely, the balance has to be removed from the balance cock. If the index has a boot, this will have to be rotated with a screwdriver in its slot to allow the balance spring to escape the index. Next, the stud will have to be removed from the balance cock by loosening the stud screw by one rotation; the stud will then just simply drop out. Place the now freed balance on a balance stake or something with a hole in that the bottom of the balance staff can pass so as not to distort the rim of the balance.

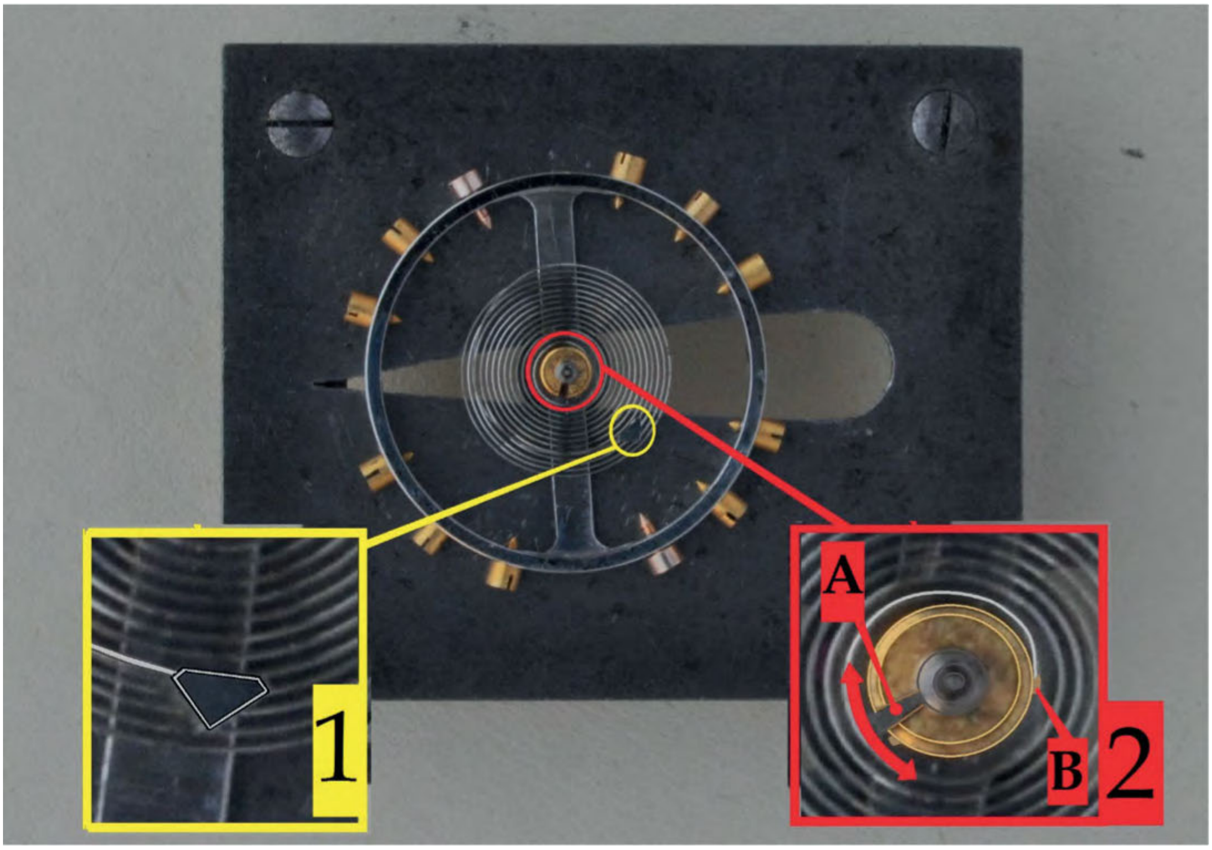


Fig. 240: Moving the balance spring collet to bring a watch into beat. (1) Stud. (2) Balance spring collet. (2A) Balance spring pinning point. (2B) Slot cut into the collet.

To make the adjustment the balance spring's collet has to be turned left or right on the balance staff. The collet has a slot cut into it in which a beat-adjusting tool can be fitted (these tools are no longer available as new, but again can be bought from internet auction sites).Alternatively, a small screwdriver blade can be used to rotate the collet, though this increases the risk of damage to the balance spring.

Once adjusted, refit the balance back on to its cock and replace it in the watch. Remember to adjust the height and centre of the spring, and make sure the spring breathes between the curb pins (as previously covered). Finally, see if the adjustment has had the desired effect. If not, try again until the desired alignment has been achieved.

Adjusting the Rate

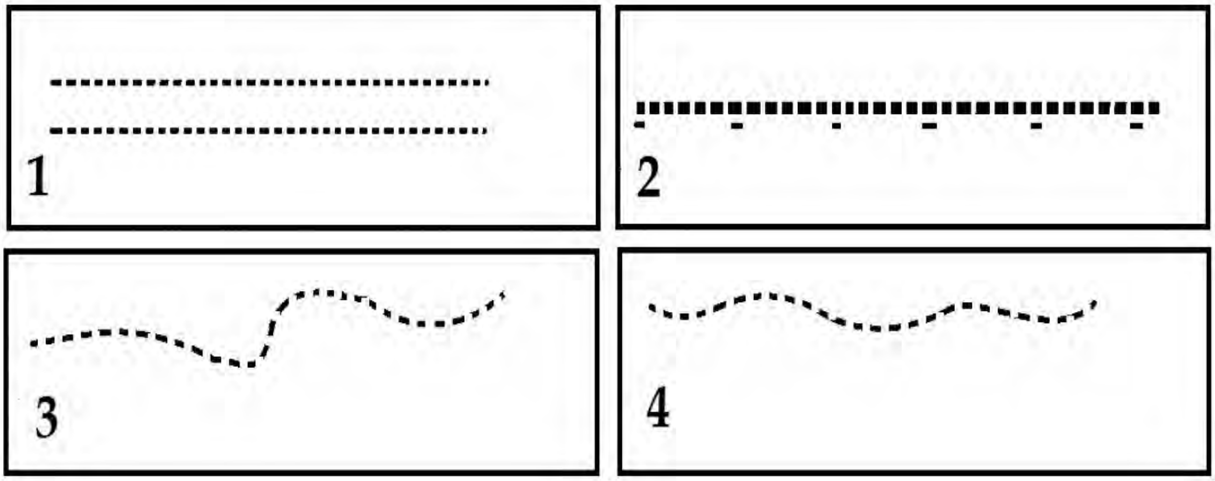


Diagram 23: (1) Out of beat. (2) Damaged tooth on the escape wheel. (3) Balance knocking. (4) Escape wheel out of round.

When making your adjustment for regulation (or rate), remember to allow time for the balance's amplitude to stabilize in between adjustments. This normally takes one or two minutes. You should also remember to move the index no more than 0.02mm at a time, as this will normally change the rate by about two to four seconds per day.

First your amplitude should be around 270–330 degrees with the mainspring wound up by two thirds, then adjust the rate of the watch with the dial facing down to a rate of plus four to plus five seconds per day. The watch should then be checked in all six positions (dial up/dial down/crown pointing up/crown pointing down/crown pointing left/crown pointing right) with an amplitude that remains fairly constant, at a gaining rate of plus four seconds per day. Failing that, the fluctuation rate should be recorded in all six positions. Add all six readings together and divide by six to work out and set the overall average.

In the diagram are some traces that will help you identify common faults.

35. CORRECT HAND-FITTING

TOOLS

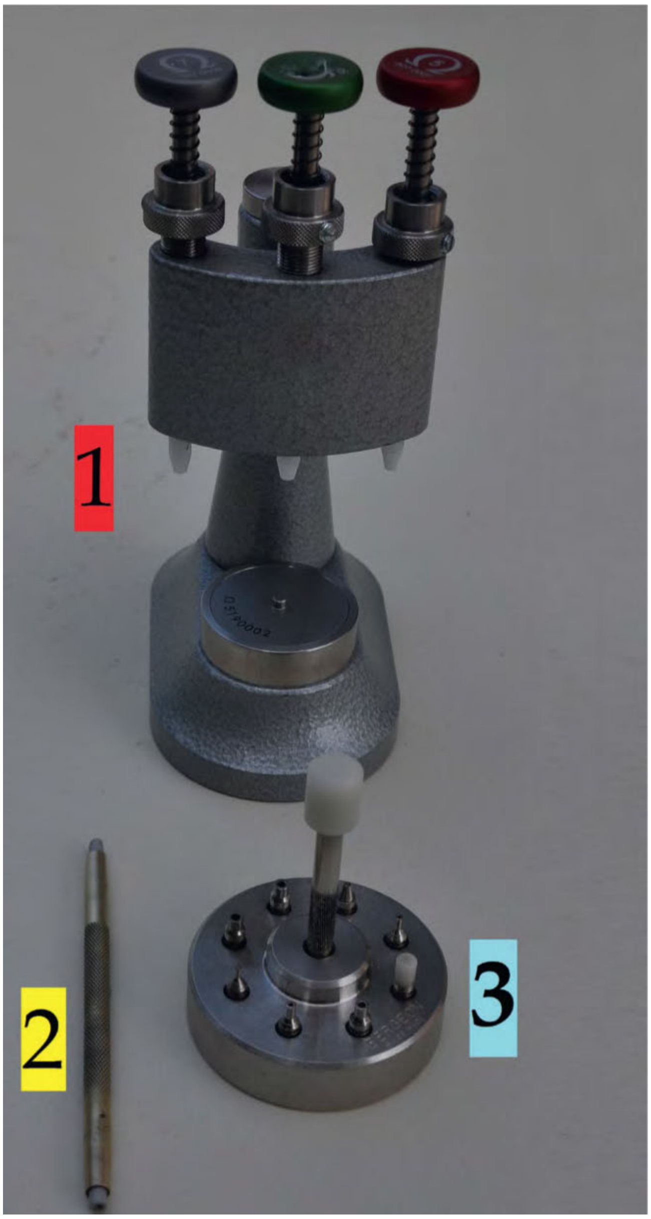


Fig. 241: (1) Horia's hand-fitting press, found in watch service centres. (2) Cheaper double ended hand-fitting tool normally found in a pack of three, favoured by hobbyists. (3) Bergeon hand fitting tool with eight different size inserts, used by professionals and hobbyists alike.

There is a variety of hand-fitting tools used by watchmakers. They also vary a great deal in price, with the most expensive being made by Horia (see Fig. 241 (1)).This is an upright tool, where the movement is held in a movement holder. The holder has a support in the centre, which prevents the jewel from being damaged during hand-fitting. The top of the tool has three different plungers, which can be finely adjusted. This has the added advantage of ensuring that everything is done at right angles, to aid correct fitting. It also provides support to limit the chance of damage occurring. The down side to this tool is that for every type of movement a watch company makes, a specially made movement holder will be needed, meaning that you have to have lots of them, making this a very expensive tool.

Next is a Bergeon tool (Fig. 241 (3)), which comes with eight interchangeable ends. This happens to be my preferred tool, and I use it in combination with Bergeon's movement holder for fitting hands (model no. 5409) as this has an adjustable support for the centre wheel, so it can be used on any type of movement.

Another tool is made by Horotec (Fig. 241 (2)). This is a pair of double-ended pushers, with one flat end and three other ends with different sized holes. The one in the picture is in fact a homemade one that I made in college, pretty much the same as the Horotec version, the difference being that theirs is finished with a red anodized coating.

A SUBSIDIARY SECONDS HAND DIAL

With a watch of this type you should always fit the seconds hand first. Place the tube of the seconds hand on top of the extended pivot that protrudes from the movement, just short of the dial.

Ideally, use hand pushers for the next steps, and use the variety that has a flat end. Push the hand down close to the dial, but leaving some clearance between the dial and the seconds hand. It is important that there is this clearance, otherwise the hand may catch on the dial and damage it, and alter the timing of the watch. This clearance is usually about the thickness of a piece of paper.

Also take the time to check that the hand itself is straight after fitting. If there is any bend to the hand, very carefully use your tweezers to correct the curve.

The next step is to fit the hour hand. This is fitted over the seconds hand (normally at six o'clock) to ensure clearance of these hands, too.

Find a hand pusher that has a similar hole to that in the hour hand, but slightly smaller if possible. This is used to push the hour hand down. Normally this is pushed right down level with the end of the hour wheel pipe. It may be necessary to push this up a little further, but you will not know this until you have fitted the minute hand. Remember again to adjust the hour hand (if necessary) to ensure it is completely flat. F-tweezers are typically used for this function (see Chapter 1 on tools for an example of these tweezers).

Finally the minute hand is fitted. Set the hour hand at twelve: this makes it easiest to see the clearance between the hour and minute hands. Rest the minute hand on top of the exposed cannon pinion. Using the flat-ended hand pusher, push down the hand as far as it will go. It should be stopped by the end of the cannon pinion. This hand should then be adjusted for levelness. If all has gone well, the distance between the hands will all be equal. If this is not the case, the hands will need to be removed and adjusted accordingly.

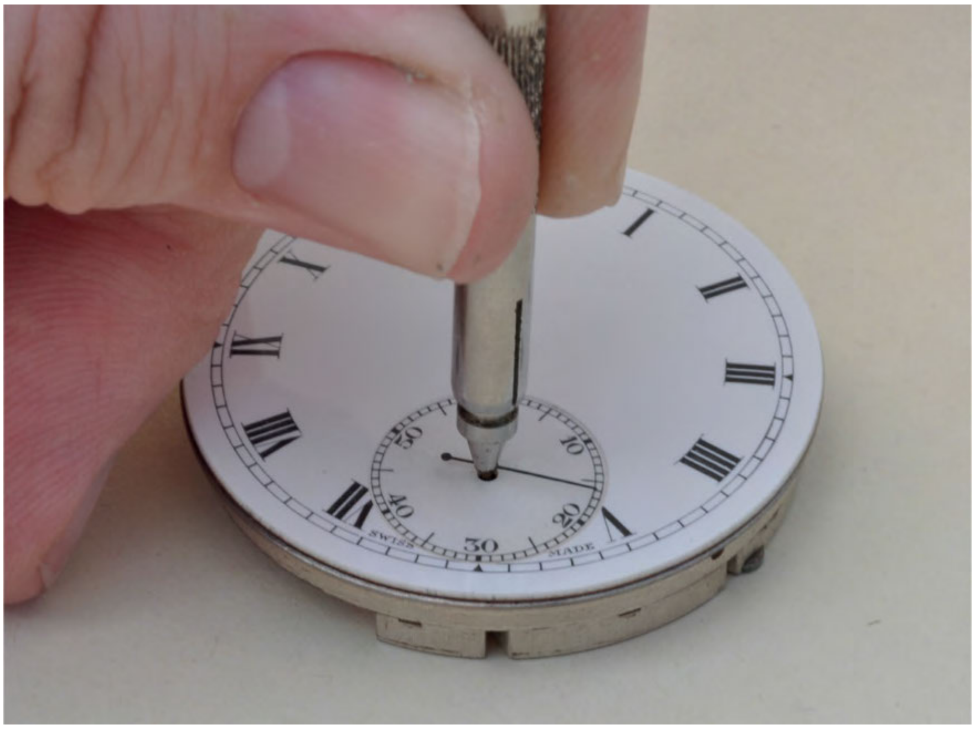


Fig. 242: Refitting the subsidiary seconds hand.

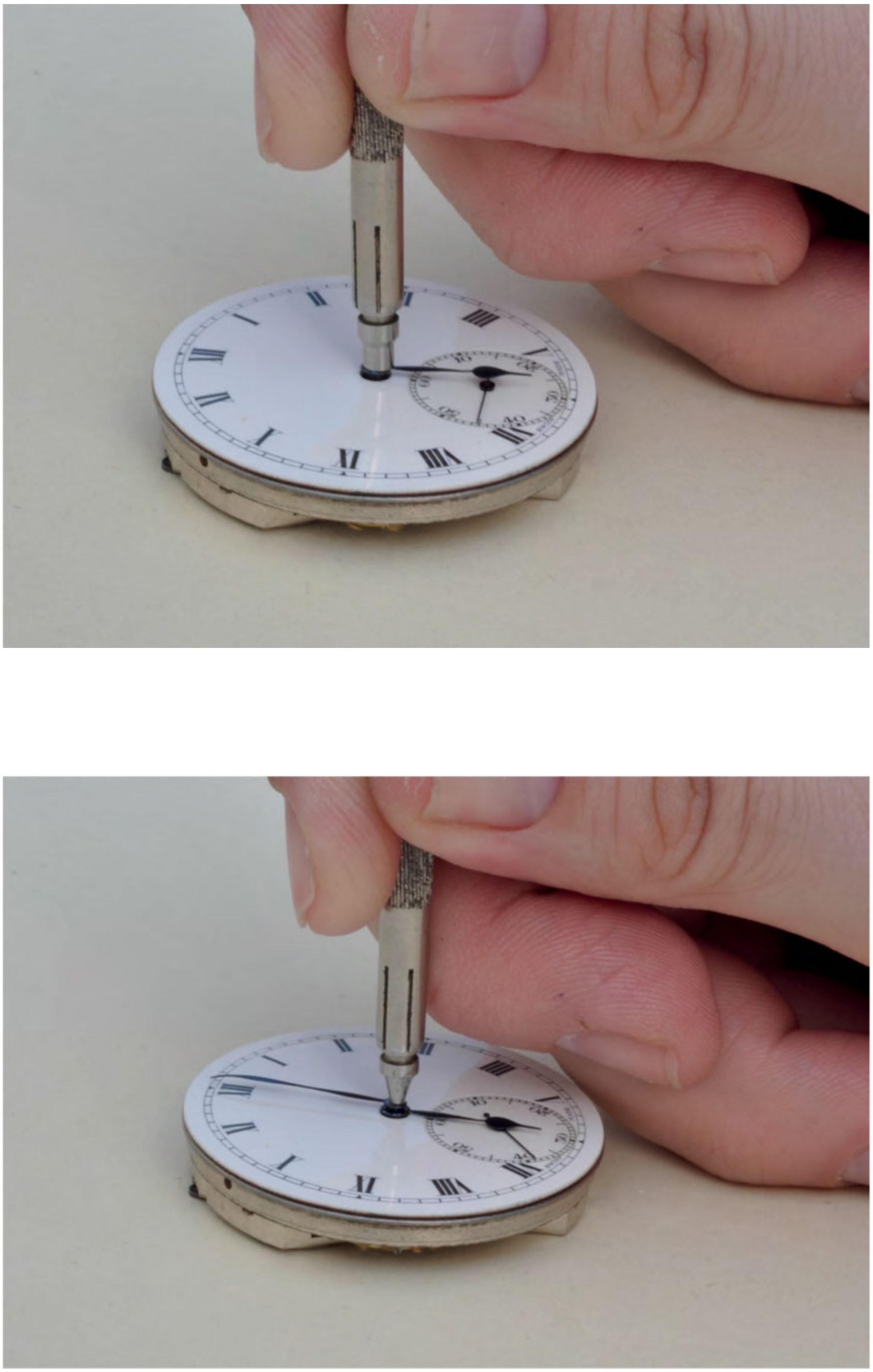


Fig. 243: Refitting the hour hand.

Fig. 244: Refitting the minute hand.

CENTRE SECONDS HAND

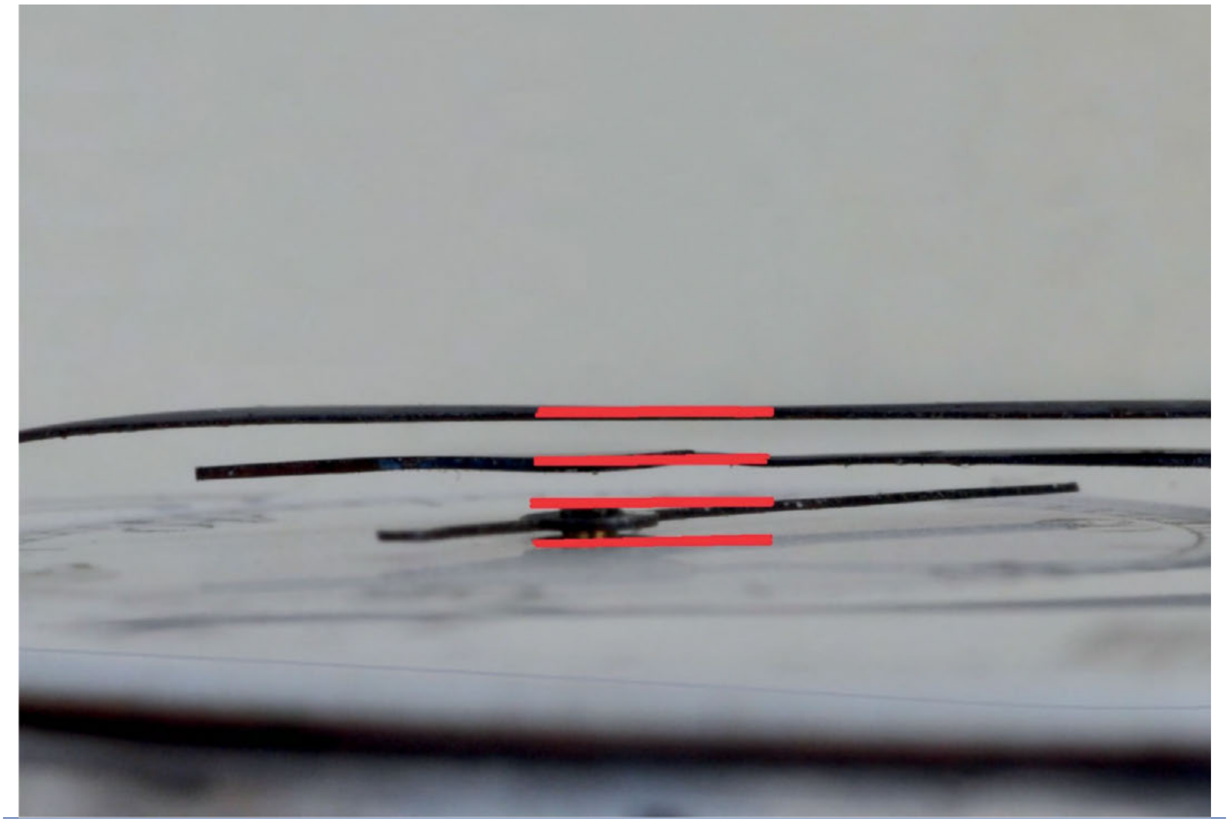


Fig. 245: Clearance between the hands and the dial.

Fit the hour and minute hands as described previously, ensuring that the clearance between the two hands is equal. The seconds hand is then placed on to the centre seconds pivot, which is poking through the hole in the cannon pinion. Using a flat hand pusher, push down on the seconds hand. This time, the hand is pushed down so that the clearance between the seconds hand and the minute hand is the same as the minute hand and the hour hand.

PART IV: COMMON REPAIRS

36. REPLACING A MAINSPRING

REPLACING A BROKEN OR DAMAGED MAINSPRING

The mainspring is one of the most important parts of a watch, and one that is most frequently overlooked by both professionals and hobbyists. Most commonly the repairer has a watch with an obscure fault they can't locate, and so almost as a last resort they replace the mainspring with a stronger one, sometimes so thick that the watch only runs for six hours, because it takes up so much room in the barrel. I guess they thought, 'Hell, it works!' and then sold it on line (we have all bought a 'pup' from an internet auction…).

The problem is normally due to an inexperienced or lazy watch repairer making the mistake of thinking that they obviously know better than the person who designed the watch in the first place. As a matter of good practice, I always make sure that the watch has the spring that the manufacturer recommends. If you wish to do the same you will need a book called *General Resource Mainsprings* or the 'GR' book. (As far as I am aware, this book is not available new in print, but it can still be sourced through internet auction sites. If you have the time and the resources you can also use www.generaleressorts.com; they can provide a mainspring in any dimensions you require.) This book will give you all the correct sizes of most of the watches out there according to their brand and designated calibre number. It is also very useful if you have an antique watch with a broken spring and you wish to find the nearest modern equivalent.

USING A MICROMETER

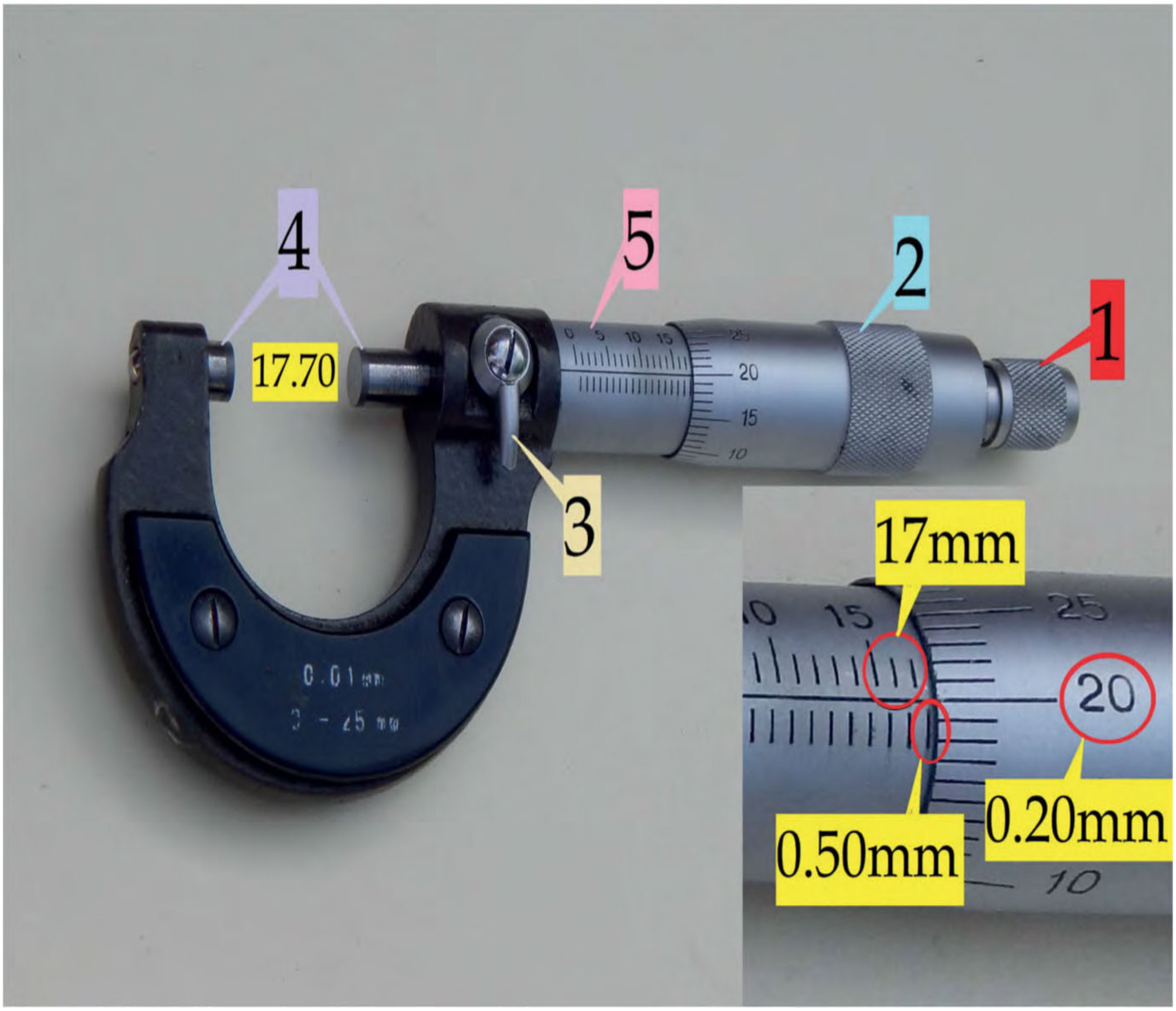


Fig. 246: Micrometer: (1) Ratchet. (2) Thimble. (3) Lock or break. (4) Jaws. (5) Scale in mm on the barrel.

If you wish to replace a spring in an old watch you will first have to measure it using a micrometer. You will need to know the following: the thickness, height and length of the spring, and the inside diameter of the barrel. The latter can be achieved with a ruler, as barrels are measured in half millimetre increments. A ruler and a good eye (possibly using an eye glass) is more than up to the task.

It is a good idea to buy second-hand, as there are hundreds of unwanted micrometers on the market, and they can be bought very cheaply.

There are two types of micrometer: metric and imperial. You will be using a metric micrometer, because nowadays an imperial type will not be much use, as any new parts are measured in metric. The easy way to find out if a micrometer is imperial or metric is to check the thimble scale (the scale on the handle): on an imperial micrometer this only goes up to twenty-four (with zero and twenty-five sharing the same indicator), able to show 0.025in. On a metric micrometer the scale goes up to forty-five (with zero and fifty sharing the same indicator), able to show 0.5mm. I will be discussing the metric type.

To use the micrometer – or 'mike' – open the jaws (Fig. 246 (4)) using the thimble (2). Hold it by the frame in your left hand, and turn the thimble with your right hand, towards you. Open it up just slightly larger than the piece being measured. Close the mike using the thimble, this time turning the ratchet (1) away from you; this will prevent you from overtightening the mike. Using the thimble will make sure that you don't damage the tool or the piece being measured, as the thimble has a slipping clutch inside.

How to Read a Micrometer

Observe the thimble. It has a ruler-type scale engraved on its surface, with corresponding numbers running from zero to forty-five. Each line represents 0.01mm. One rotation of this thimble is equal to 0.5mm. If the jaws of the mike were closed and you rotated the thimble so that the zero line lined up with the number ten on the thimble, this would equal 0.10mm. Unwind the thimble so that the jaws of the mike are open about 1.5cm, then observe the following: each top line on the sleeve is equal to 1mm. If the thimble were rotated twice, one of these lines would be revealed. Two more revolutions of the thimble would reveal another line, and this would be equal to 2mm, and so on.

Every bottom smaller line is equal to 0.5mm. If the thimble were rotated once, one of these smaller lines would be revealed, so every revolution of the thimble is equal to 0.5mm.

Example

Fifteen turns of the thimble and twenty divisions past the zero line is equal to:

15 = 7.5mm

20 = 0.20mm

17.5 + 0.20 = 17.70mm (see Fig. 246)

Care of your Micrometer

When using your mike, make sure that anything you measure is clean, including the mike's anvil and spindle. You must also check that when the mike is screwed up closed, it has both zero marks lined up, otherwise you will end up with a false reading.

To clean the mike, close its anvil and spindle on a piece of clean paper lightly, then slowly pull the paper out. If the jaws still look to be covered in grime, dab a finger-size dot of oil on the paper, then repeat the previous process and the oil should help clean off any remaining dirt.

Tip: When ordering a replacement mainspring from a supplier, find the GR number reference and try using the website's search bar. Type in this number with or without GR at the front of the number: this can be a lot quicker than running through the pages and pages of mainsprings available.

FITTING A NEW SPRING

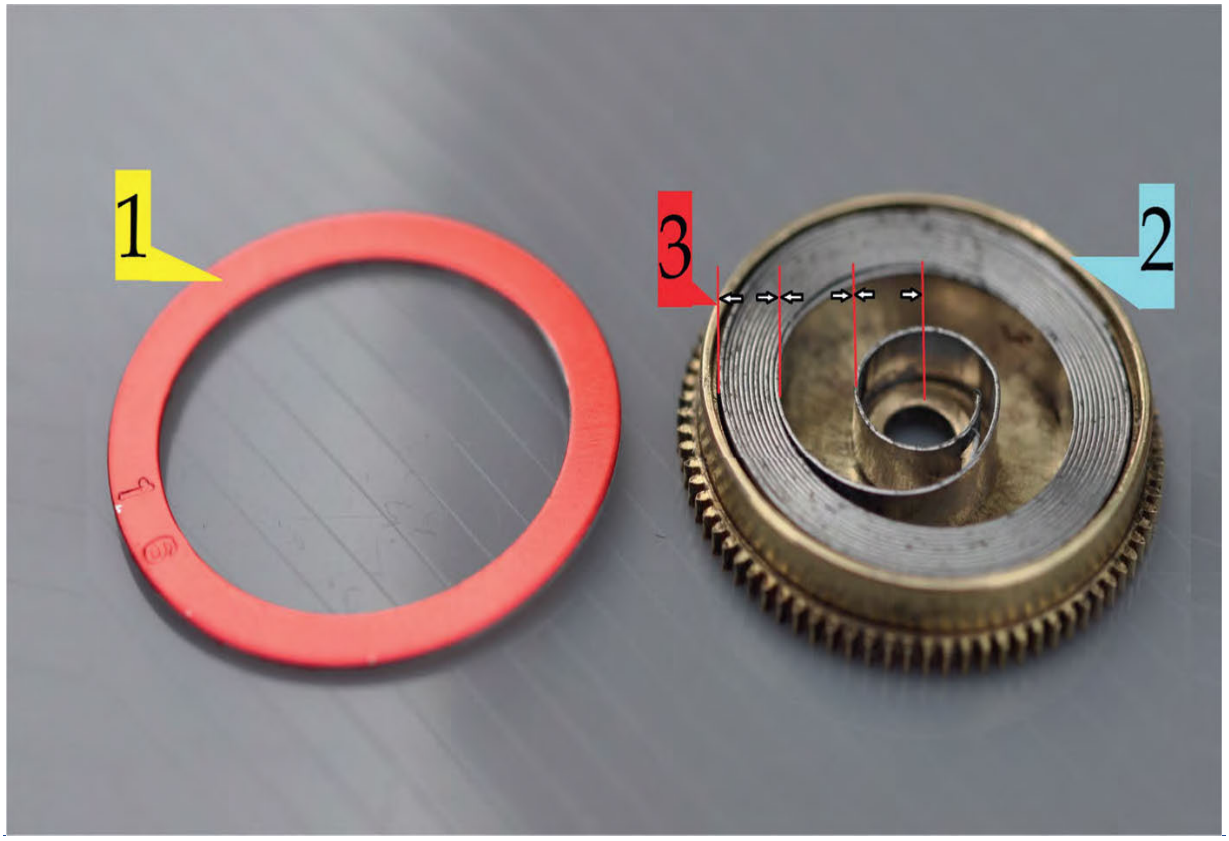


Fig. 247: (1) Ring in which a replacement spring is held captive. (2) Barrel with a correctly proportioned spring fitted. (3) The equal proportions required: each space represents a third measured from the centre.

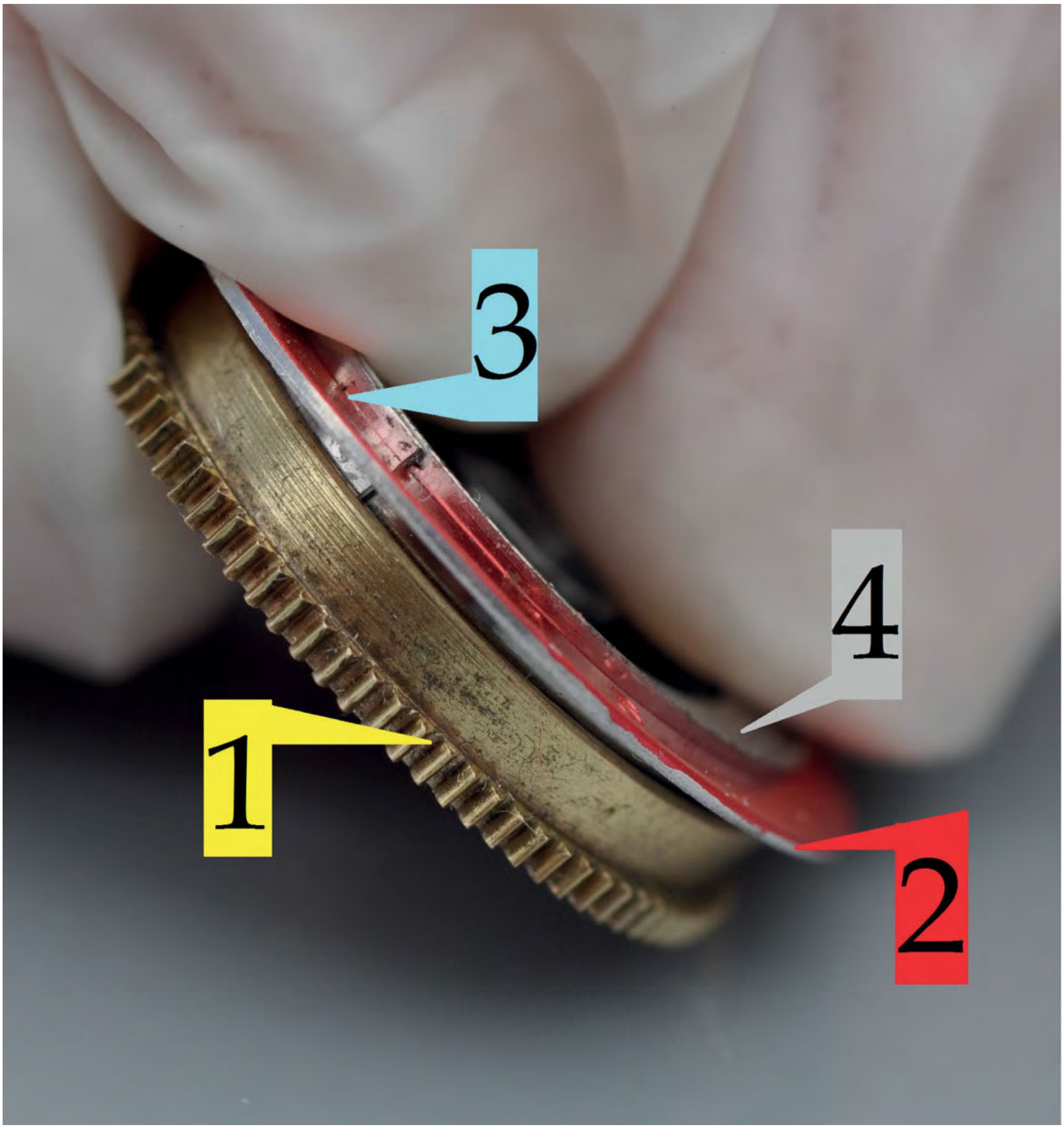


Fig. 248: Pressing a new spring into the barrel. (1) Barrel. (2) Retaining ring. (3) Mainspring hook. (4) Mainspring held captive in the retaining ring.

If you have the misfortune to damage the spring during fitting and you haven't got a mainspring winder, the best option is to buy a new one. This will come in a sealed packet, and is pre-wound and fitted into a retaining ring. Place the spring over the barrel and push it in – and job done! If you suspect the spring is of old stock, it would be advisable to remove it from its retaining ring and clean its surface with a degreaser, and then fit it into the barrel using a mainspring winder.

37. REPLACING A CROWN AND WINDING STEM

There are four main types of crown: water-proof, dust-proof, non dust-proof or pocket-watch crown, and screw-down.

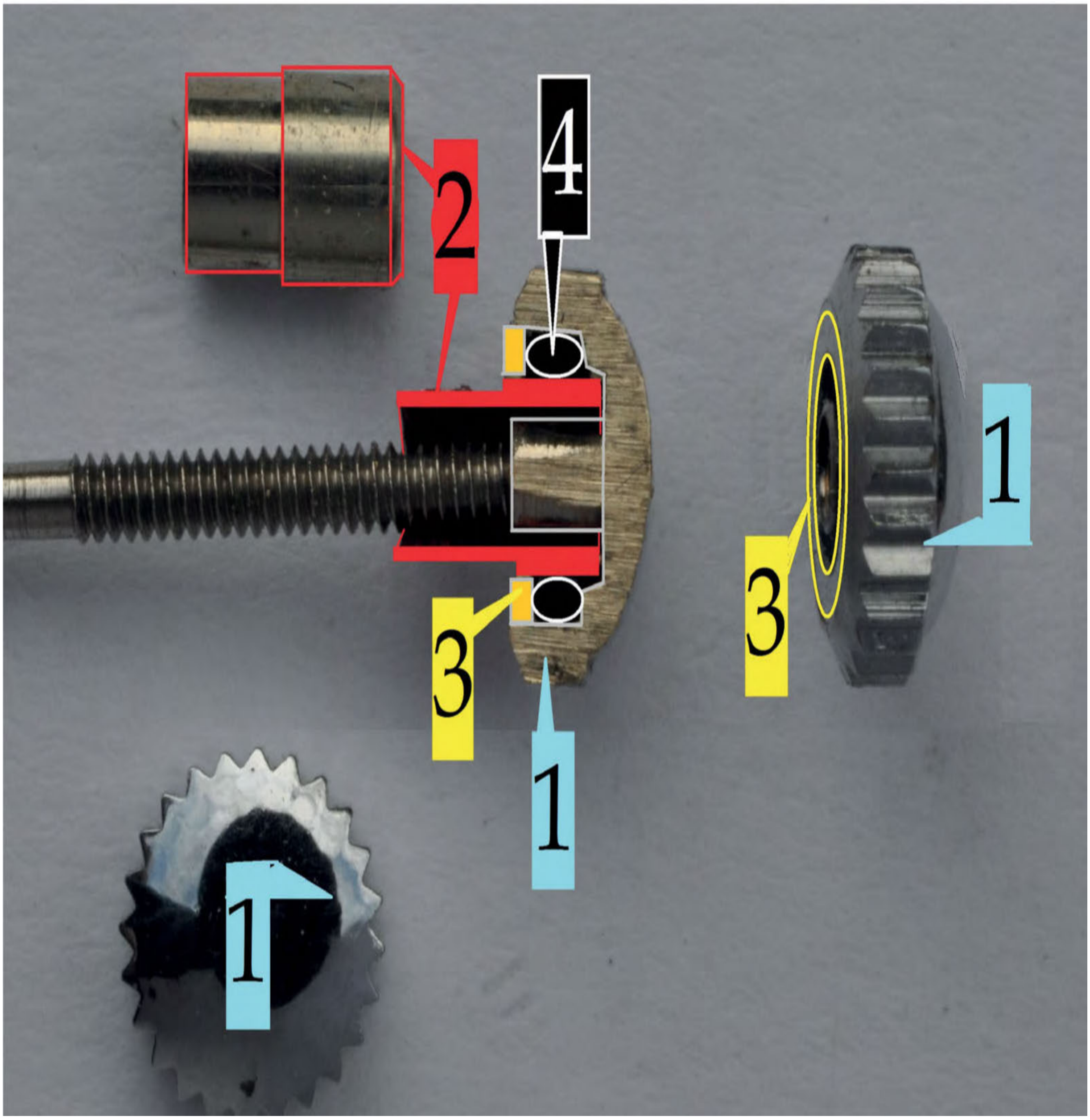


Fig. 249: Water-resistant crown or button. (1) Crown. (2) Pendant tube. (3) Retaining washer. (4) O-ring or seal.

Water-proof crown: This is the most common type of crown found in wristwatches, where the watch case has been designed to keep out moisture or water. The majority of modern watches now have a water-resistant case, and this type of crown is commonplace. The Swiss and the

Japanese use distinctly different crowns, but they basically do the same job. The inside of the crown has been cut out to accommodate a rubber O-ring, which is held captive by a retaining washer. The crown then slides over a stainless-steel tube (highlighted in red in Fig. 249). This tube is pressed into the side of the watch case, and the O-ring in the crown then provides a water-resistant seal as it hugs the pendant tube.

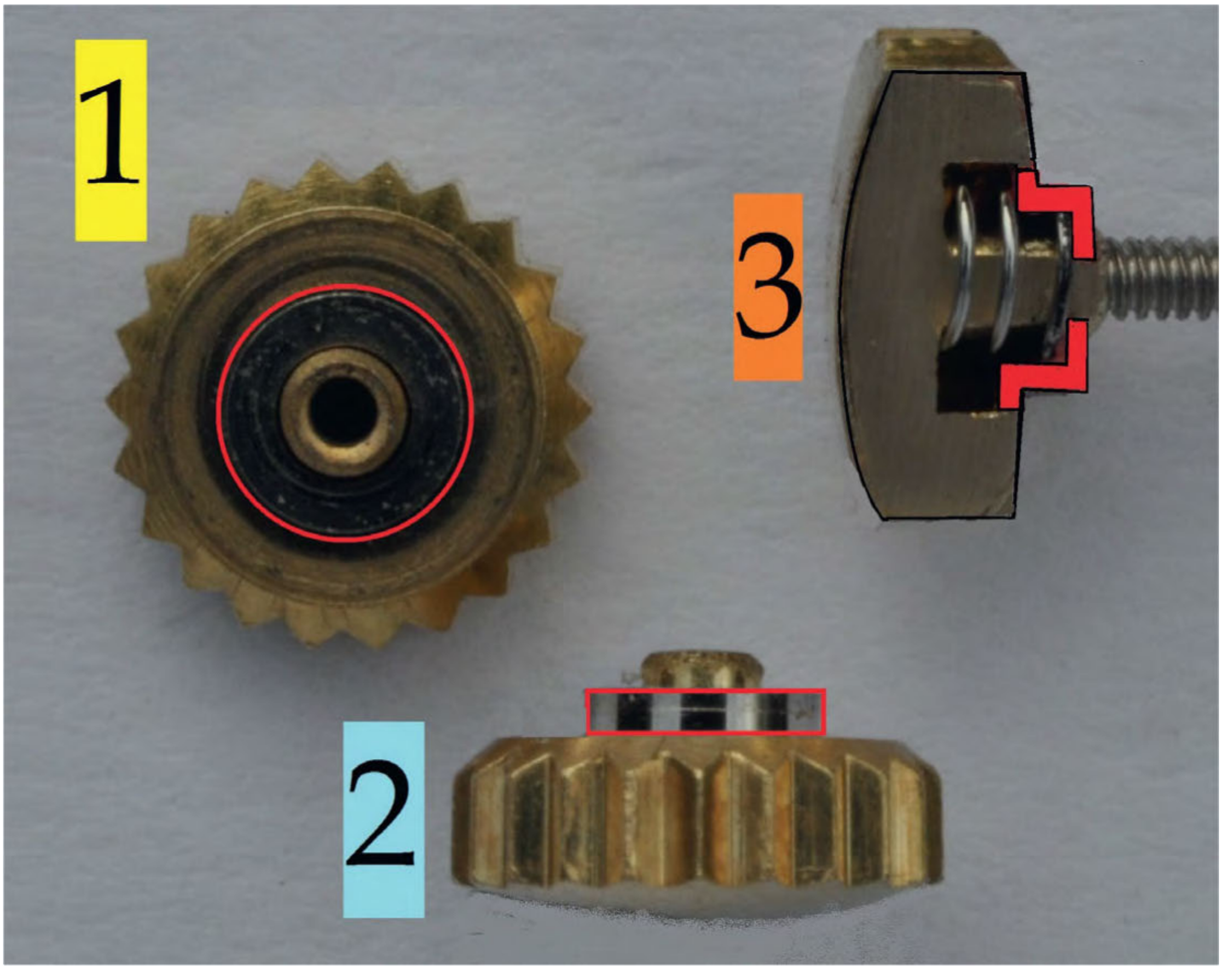


Fig. 250: Dust-proof crown. (1) View from the underside. (2) View from the side. (3) Spring-loaded diaphragm, highlighted in red.

Dust-proof crown: This type of crown is most commonly found in older wristwatches and some modern thin dress watches. As the name suggests, this type of crown keeps dust out of a watch case, but will not resist moisture or water. Inside the crown is a spring-loaded diaphragm (seen in red (3) in Fig. 250, where a crown has been cut in half), and this presses against the case to keep out dust or dirt. This diaphragm will always stay in contact with the case of the watch, even if the watch is in hand-set owing to the fact that it has a spring inside pushing it outwards.

Non dust-proof or pocket-watch crown: These crowns are basically the same as a dust-proof crown except they do not have a diaphragm or spring. As the name suggests, this type of crown is not dust proof.

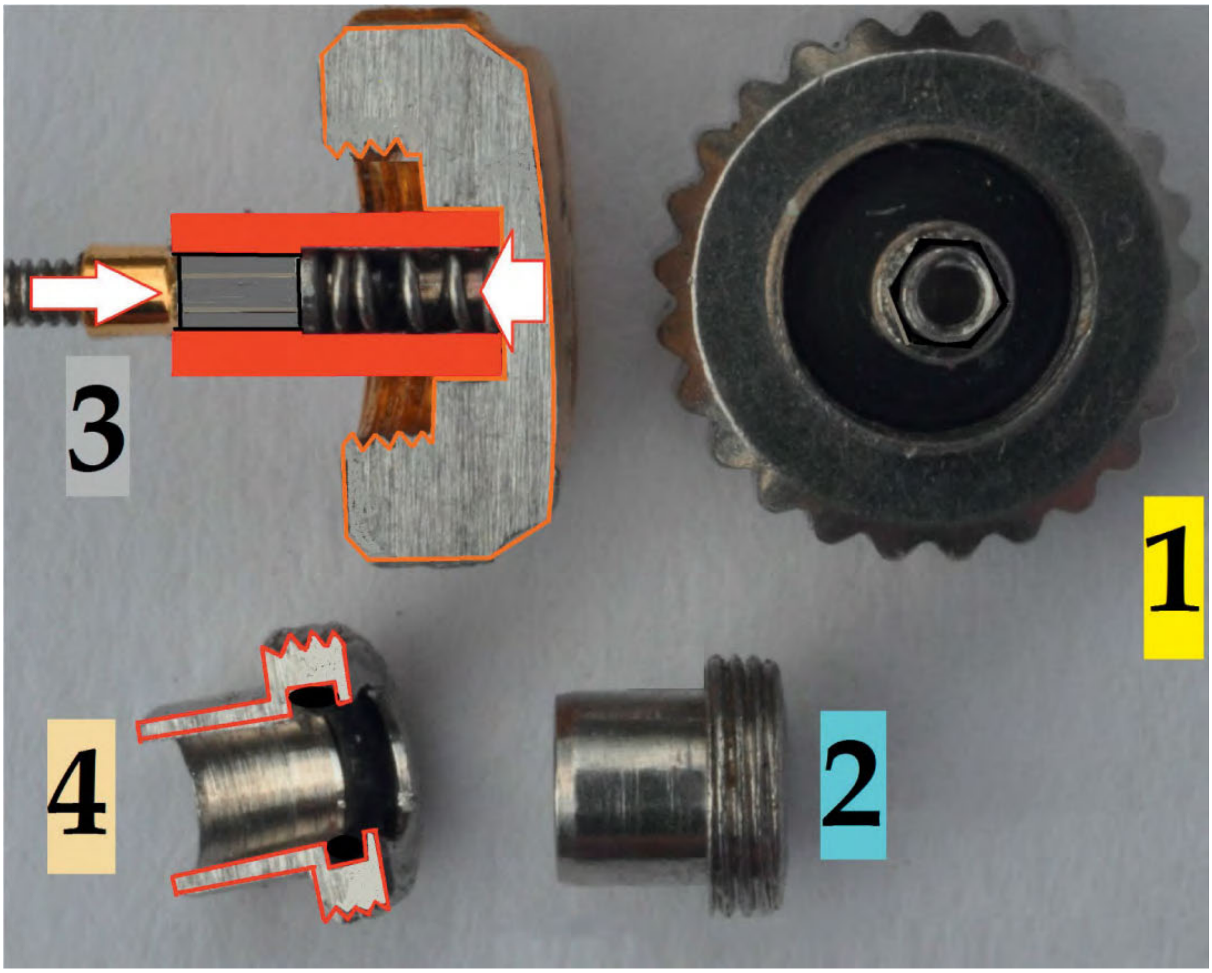


Fig. 251: Screwed-down water-resistant crown. (1) View from underneath, showing the seal in the crown. (2) Pendant tube. (3) Side view of the crown cut in half. (4) Pendant tube cut in half.

Screw-down crown: This type of crown is water resistant and is commonly found on divers' watches, owing to the fact that it can have two or three seals. One or two seals will be fitted in the pendant tube, and another one inside the crown.

The pendant tube is pressed and glued (or sometimes screwed) into the side of the watch case, and is normally made from stainless steel. It extends out of the watch case to support the winding crown, and has a water-resistant O-ring fitted in its end (as seen in Fig. 251 (4), where the tube has been cut in half).The shaft of the winding crown passes through the O-ring of the pendant tube to make a water-resistant seal.

Inside the body of the crown is another O-ring. This is compressed when the crown is pushed up against the pendant tube, and then screwed down to lock the crown. The crown has a telescopic tube and a sort of clutch that prevents the stem rotating when the crown is pushed up against and screwed on to the pendant tube.

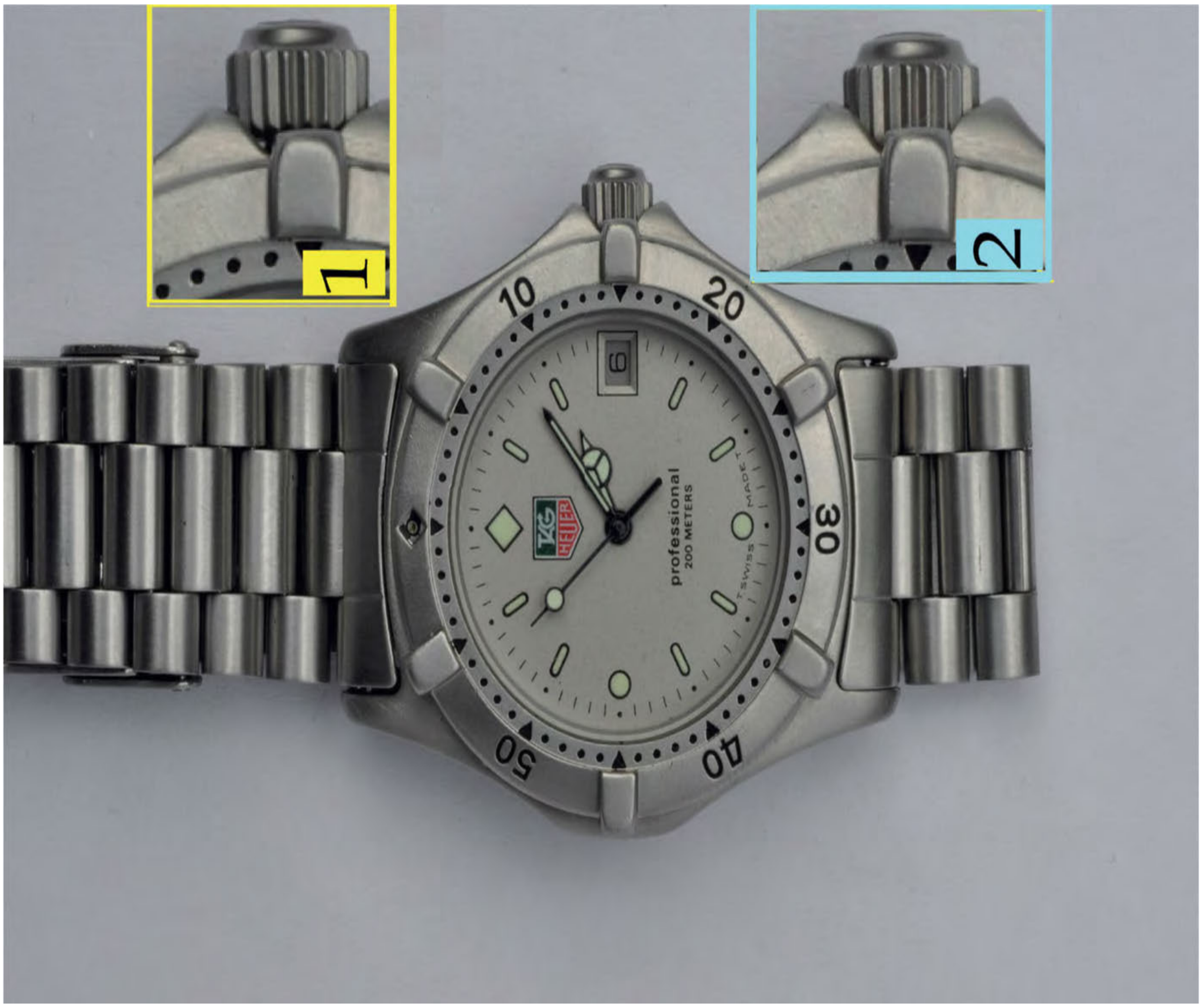


Fig. 252: (1) The crown unscrewed. (2) The crown screwed in.

SELECTING A REPLACEMENT CROWN

A replacement crown can normally be purchased from the manufacturer of the watch. This certainly makes life easier, as it is usual to find that they are company specific and tend to have the manufacturer's logo or name decorating the end of the crown. If the crown is unmarked, then a generic one can be fitted. Most material suppliers have a reasonable range of crowns to choose from.

If you can't obtain a replacement crown from the manufacturer via its model number, you may be able to purchase one from a materials dealer or through internet auctions. First you must establish which type you need, then the material the crown is made from: this can be anything from 9ct, 14ct or 18ct gold, or it may be gold plated, rolled gold, chrome plated, stainless steel, or some type of PVD plating. This may be engraved on the case somewhere.

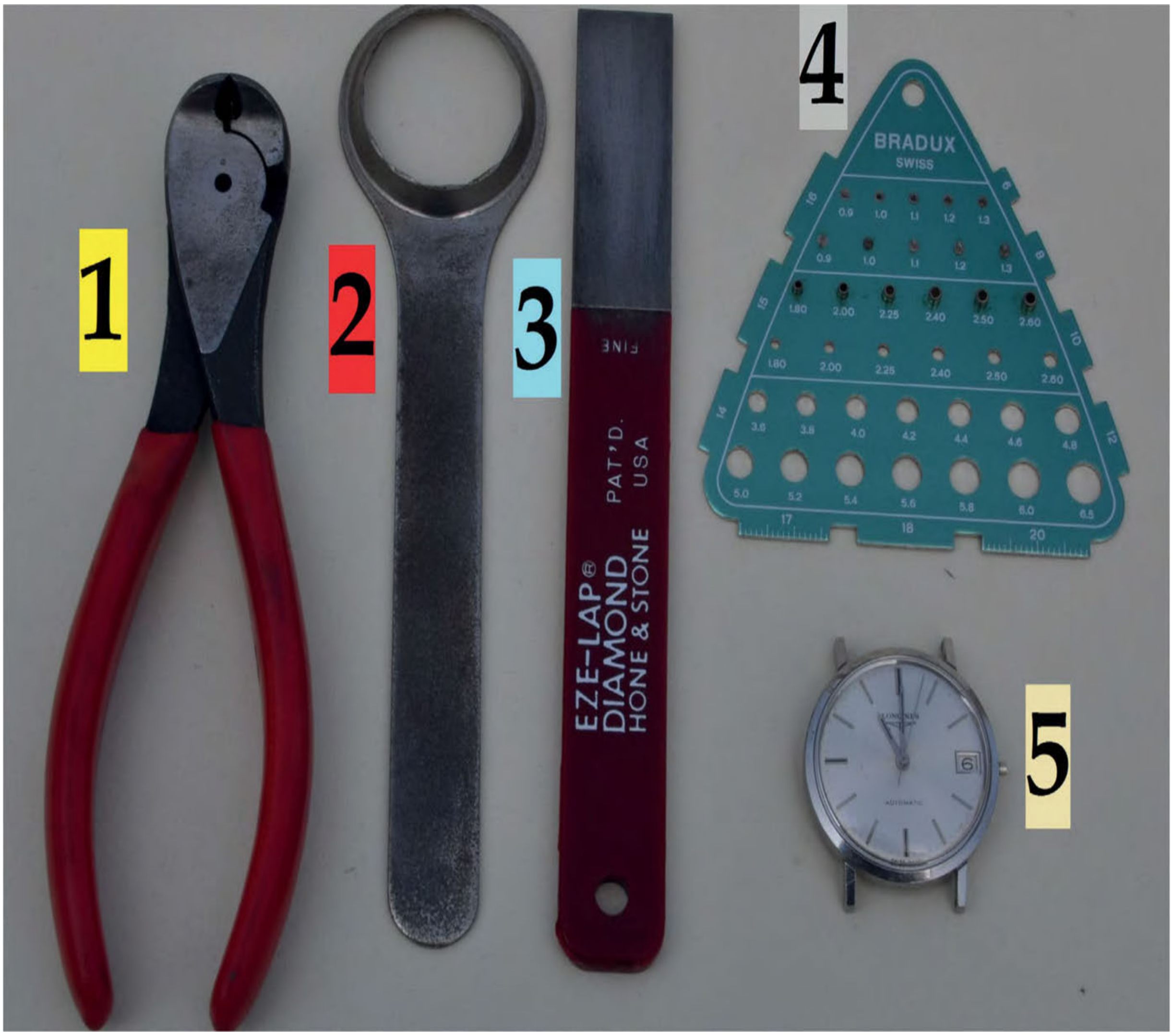


Fig. 253: (1) Cutters. (2) Case spanner. (3) Diamond file. (4) Crown gauge Bergeon 6740. (5) Watch that needs a new crown.

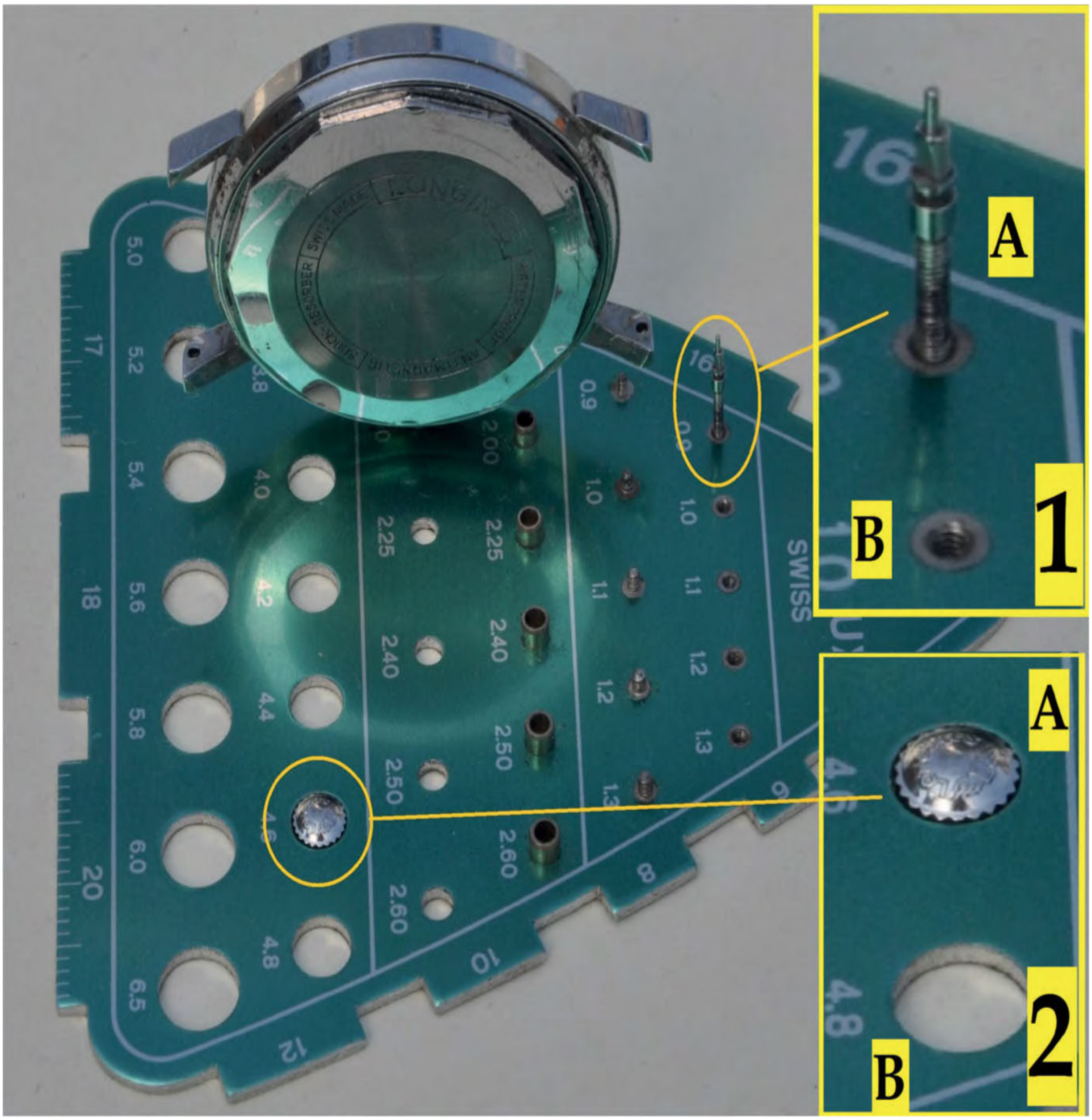


Fig. 254: Bergeon crown gauge – great for grading a job lot of crowns and handy for measuring the threads on a stem. Ideal for the days you have to order a replacement crown. The main image shows a watch case pendant tube being measured. Image 1A shows the thread of a stem being measured: Image 1B shows the hole in which the stem is screwed in to: Image 2A shows a crown being measured and 2B shows one of the many holes used to measure.

You will then need to measure the diameter of the crown: this can be done using your micrometer, a digital vernier gauge, or a watch crown gauge made by Bergeon (model number 6740) (see Fig. 253 (4)).

Finally, you will need to know the tap or pitch of the thread on the winding stem which the crown is to screw on to. This can only be measured by using a screw thread gauge. All modern mechanical watches (made in the last thirty years) tend to be a Tap 9 stem, though occasionally a chronograph will have a Tap 10 or 12 stem. As the Bergeon crown gauge is quite expensive, you may choose to buy several crowns with different tap sizes, and keep them in packets with that tap size written on them, so you can use them as a gauge.

CUTTING AND ADJUSTING THE LENGTH OF THE STEM

To adjust the length of the stem you will need to open the watch case, and to do so you will need some type of case opener. The watch I have used for this is a Longines with a screw-back case. The second item in Fig. 255 is the case opening key that Longines made to open the case.

Once in the case you will probably have to remove the old stem or crown that you are replacing.

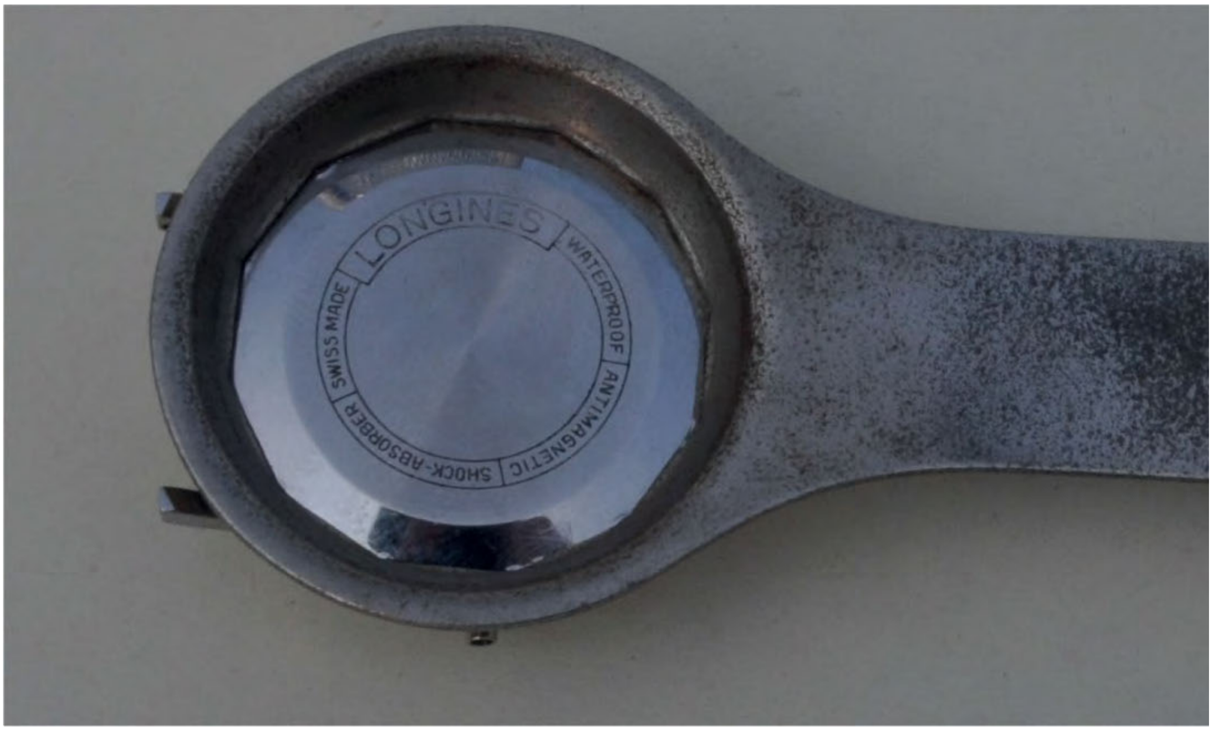


Fig. 255: Longines being opened with a traditional case spanner (a Jaxor tool will just about do the job, but with a high risk of scratching the back).

If you are re-using the original crown or stem, then you will have to separate the crown from the stem. To do this you will have to hold the stem in a pin vice, holding it just before the threaded part as this is the strongest and fattest part of the stem. The crown should simply unscrew with a little resistance. If it puts up a fight it may have been glued with Loctite, and in order to free it you will have to heat it up slightly with a lighter in order to break the bond of the glue.

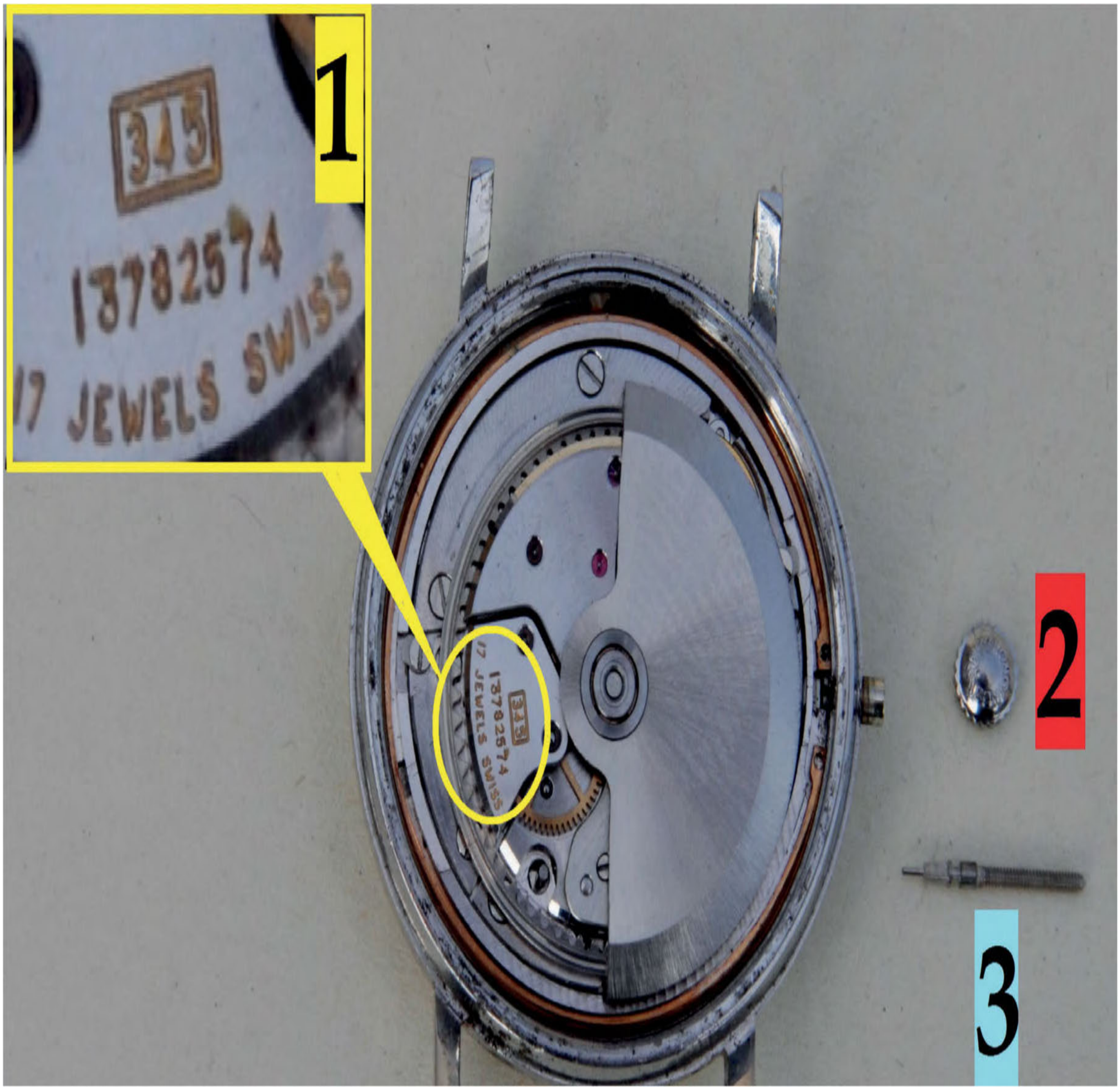


Fig. 256: (1) The calibre number (top) and the serial number (bottom). (2) Replacement Longines crown. (3) Replacement stem.

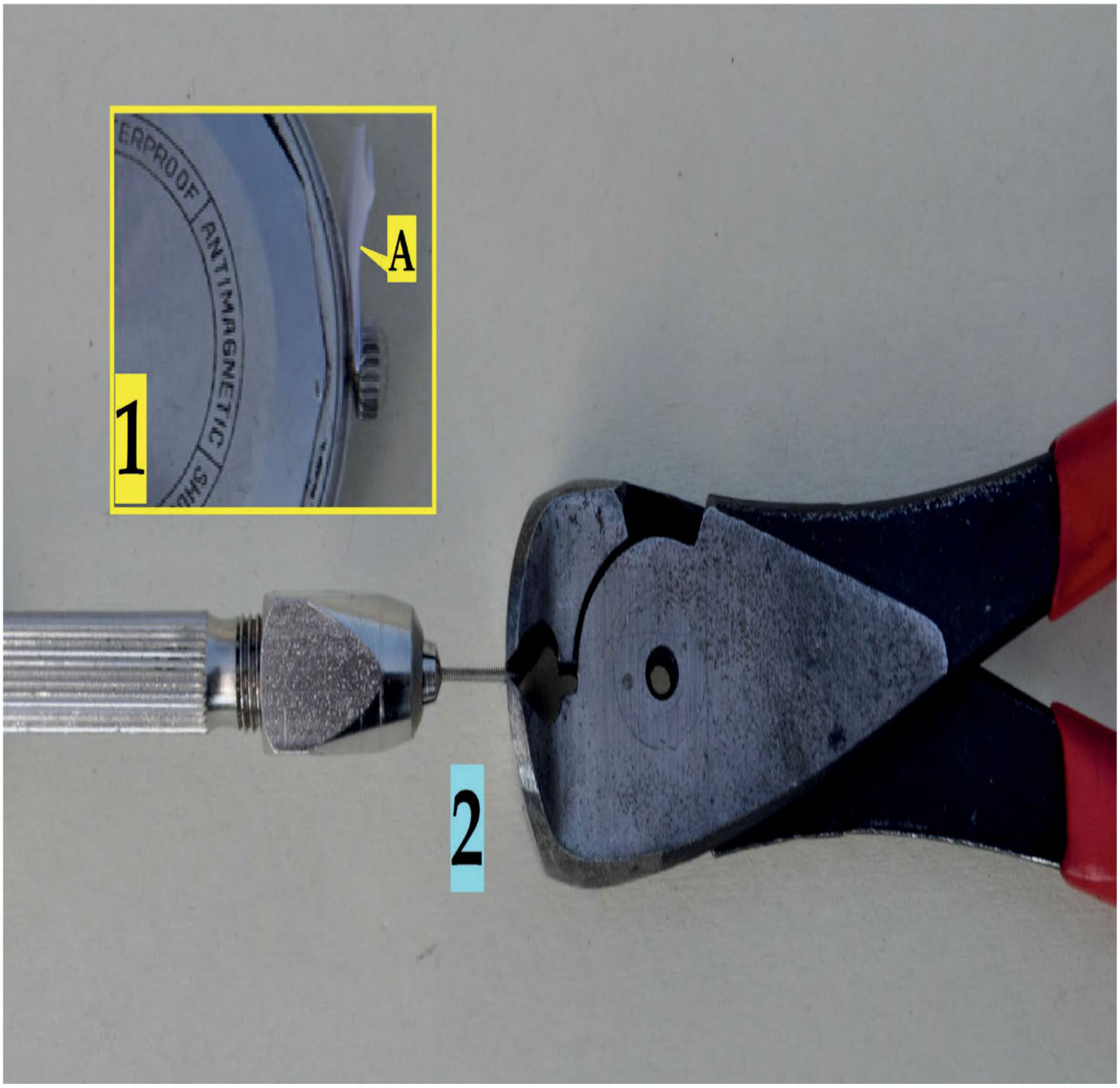


Fig. 257: Image 1: The clearance between the case and the crown, indicated by a piece of paper. Image 2: The stem being cut with cutters.

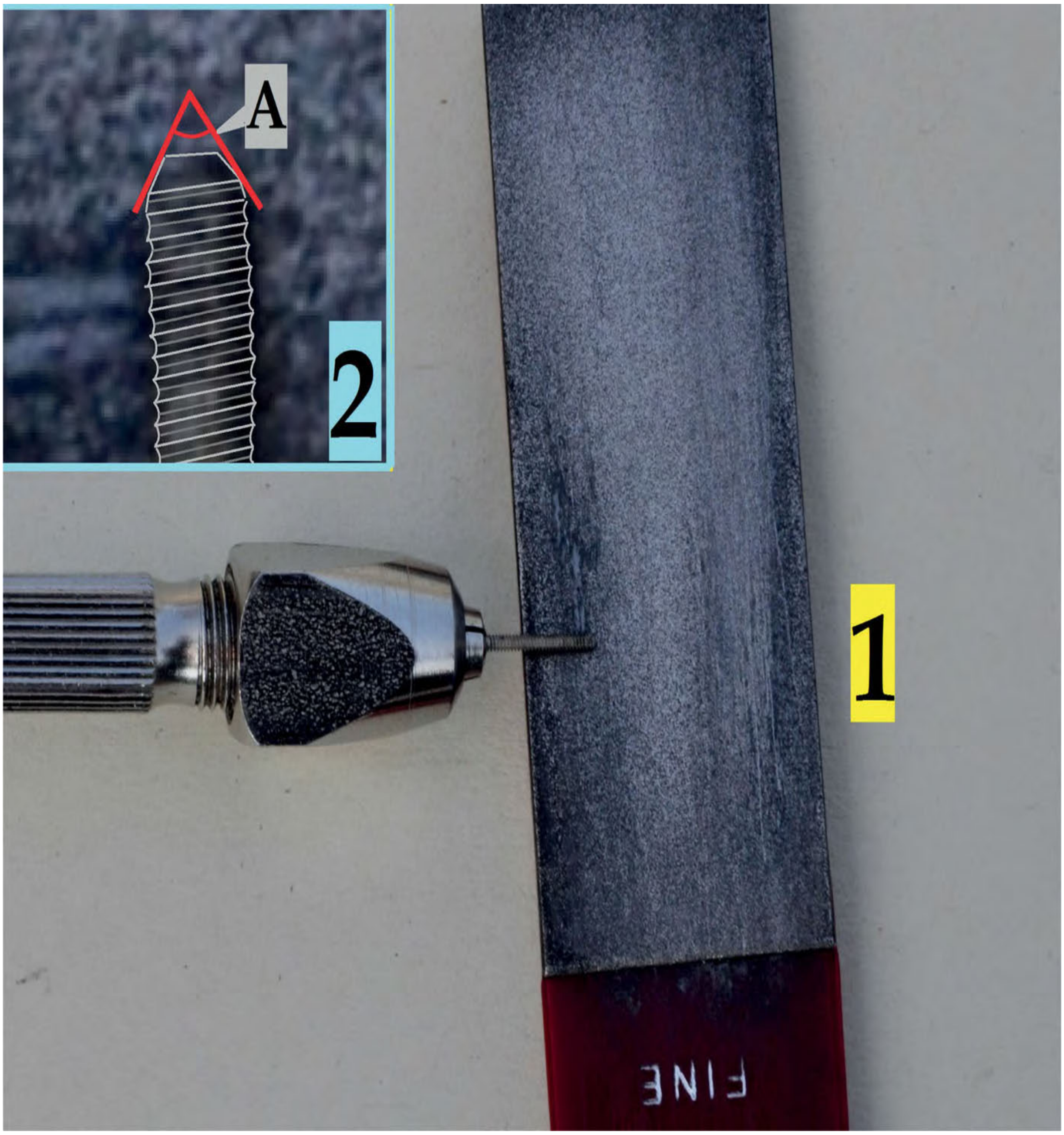


Fig. 258: Image 1: A chamfer being filed on the stem. Image 2: The angle of the chamfer (A).

Loosely fit the new stem and crown together, and fit them in the watch in order to see by how much you will need to shorten the stem. Roughly measure with a ruler how much you will need to cut off.

Roughly cut the stem to length (using side or end cutters bought from any DIY shop), leaving it just 1 or 2mm longer than needed. File it to the final size using a diamond file or oilstone. Be sure to test fit throughout the whole process. When the crown is fitted on to the stem, and this is fitted into the watch, there should be the clearance of a piece of paper between the crown and the watch case. The crown is normally glued to the stem with a tiny drop of Loctite 603 and screwed up tight.

Tip: Before fitting the crown on the stem, it’s a good idea to remove the burr on the end of the freshly filed stem. Do this by filing a chamfer (bevel) on the end of the stem. Use a sharp knife to run around the end of the thread to break off the final bur.

Tip: If you have the misfortune to shorten the stem even very slightly, this can be remedied by using electrical solder. Take your case knife and cut off a little breadcrumb size of solder, and drop this inside the hole of the button. This is used as a packing piece; the stem will still screw up tight and can be glued as well.

38. FITTING WATCH GLASSES

‘UB’ GLASSES

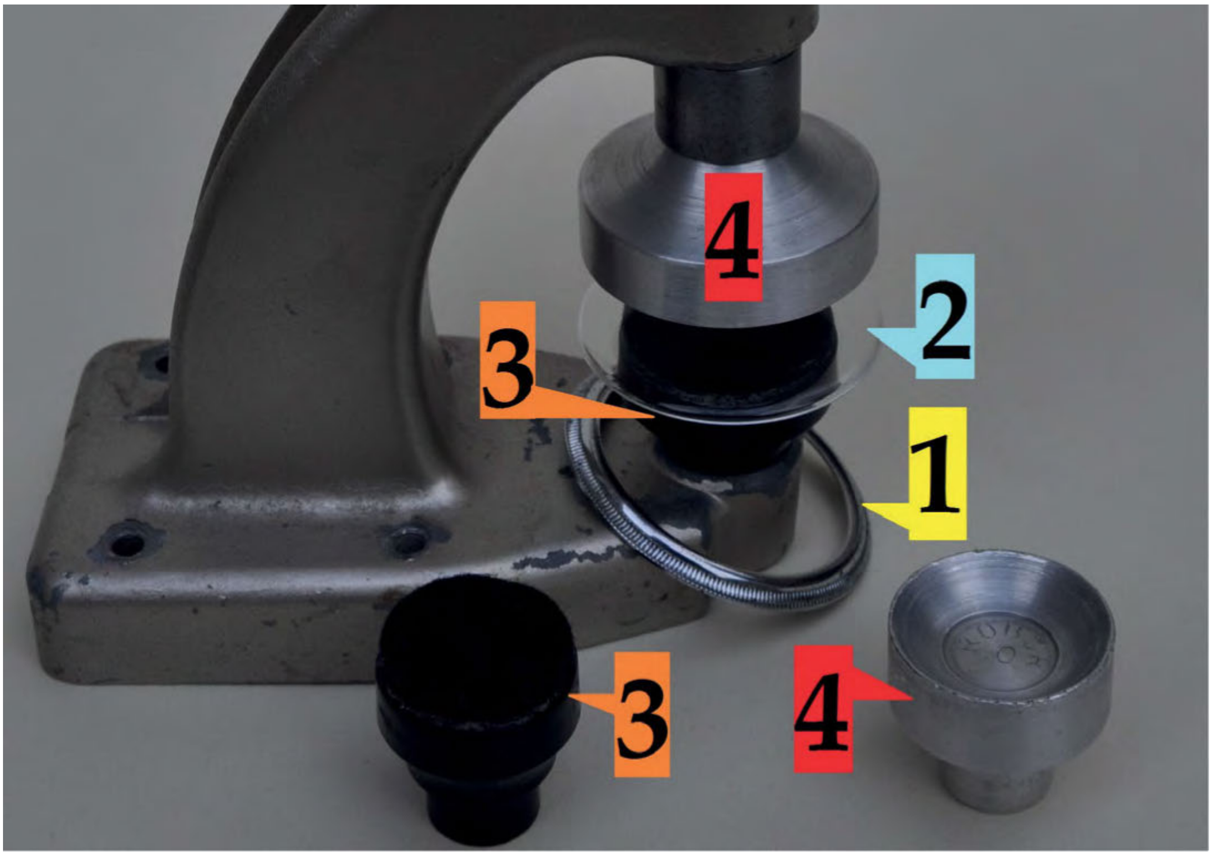
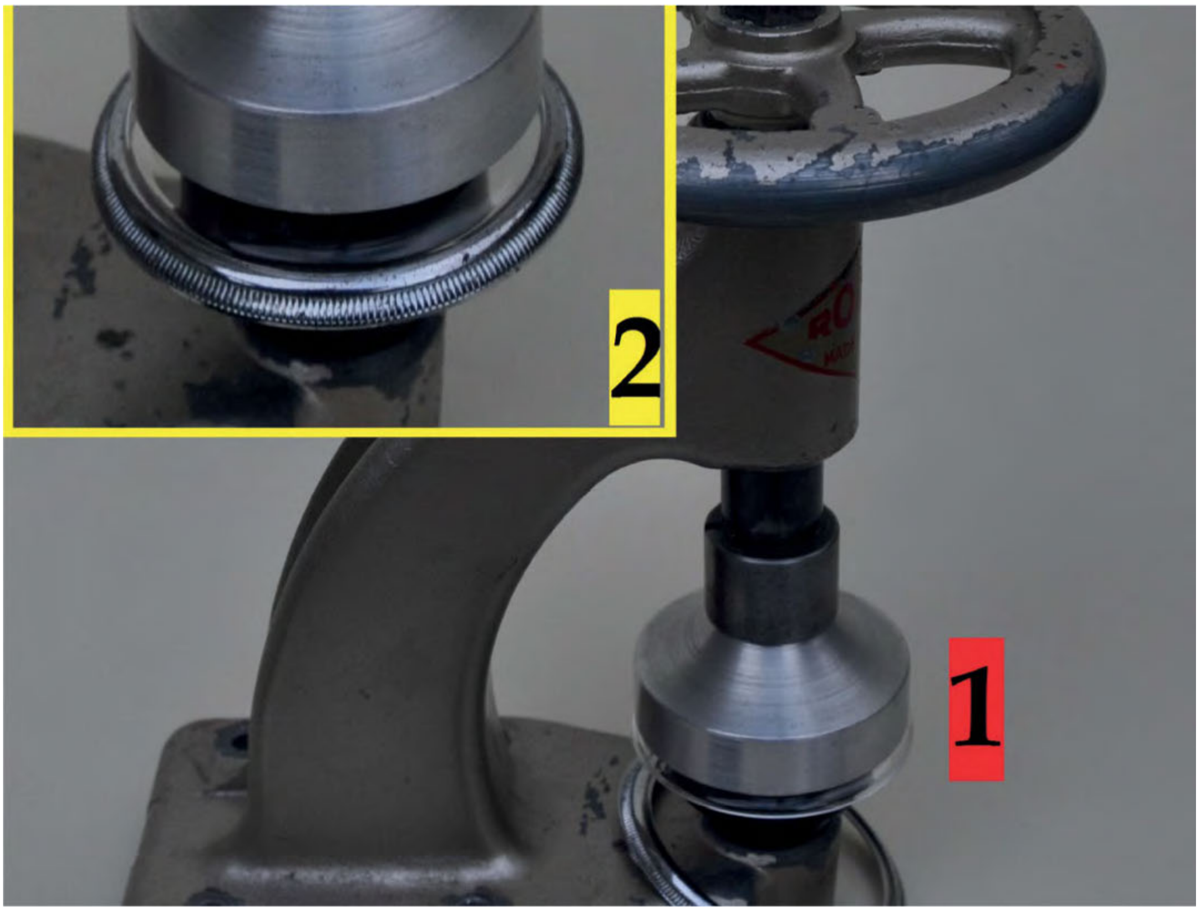


Fig. 259: Fitting a plastic lens or UB in a Robur tool. (1) Watch-case bezel. (2) UB. (3) Domed stake. (4) Cupped die.

There are a few different types of watch glass. The ‘unbreakable glass’ (UB), sometimes called Plexi, is a plastic dome with a D cross-section. It has an inner milled edge, inside which sits a compression ring made of brass, finished in either gold or chrome. This type of glass is typically pressed into the case, with the inner ring pushing out to provide a water-resistant seal. The glass is generally 0.2mm larger than the bezel groove.

There are two additional non water-resistant variants of this glass, known as 'low dome' and 'high dome'.This type of glass is also a compressed fit, but it does not have the inner compression ring. The only difference between these two types is the height of the dome (as you might have guessed). These were very popular between the 1920s and 1960s, but fell out of favour with the introduction and development of water-resistant watches. Occasionally these types of glass are held in place with glue.



Fitting Low and High Dome Glasses

Fig. 260: Image 1: UB being compressed. Image 2: Bezel being fitted to the UB.

Low and high dome glasses are always fitted using a domed stake and glass press. This is normally slightly more domed than the glass, to allow compression of the glass. This compression is essential to allow the glass to fit the bezel groove accurately.

First select the correct domed die for the glass. This should be very slightly smaller than the actual glass itself. This goes in the bottom of the glass press, the case slides over the die, and the glass is then placed over the die.

Next take a cupped die and fix it in place in the top of the glass press. Press down on the handle: this will have the effect of compressing the glass. Whilst the glass is in this compressed state, the case should be lifted up to mate with the glass. The pressure is then slowly released off the handle, and the job is done. The case with the glass fitted can now be removed from the glass press.

UB glasses tend not to like being fitted using the process described above, so I would recommend using the following method: place the case on top of a cupped or flat die that supports as much area underneath the case as possible. The UB is loosely placed in the bezel groove. A second cupped die is placed into the top of the glass press; this should be larger than the glass. The handle is pressed. As the glass is pushed up into the case, it is compressed into the bezel groove. A clicking noise is often heard, so you know the glass has found its way home.

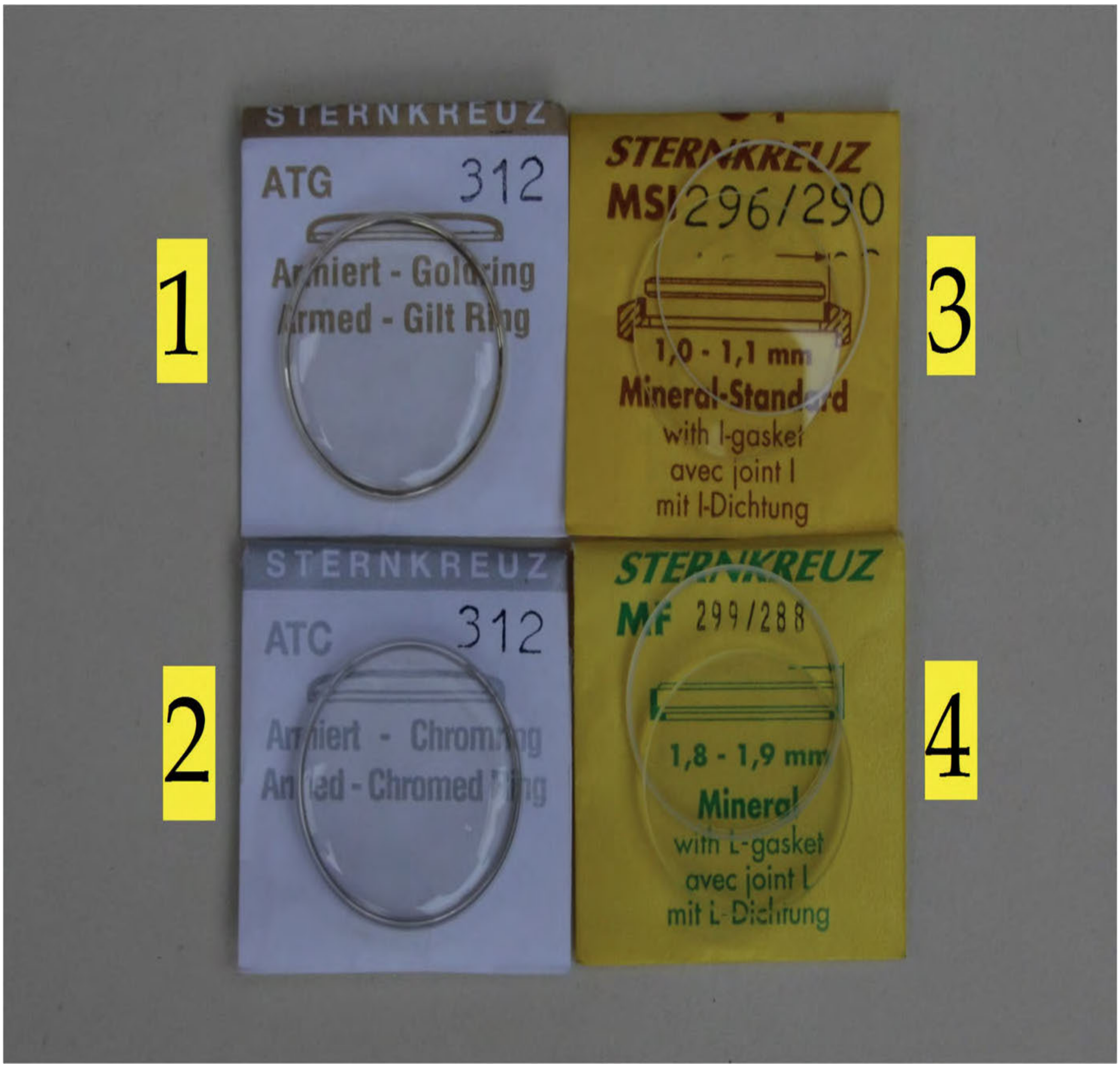


Fig. 261: (1) UB with gold-plate armoured ring. (2) UB with steel armoured ring. (3) Water-resistant MSI mineral glass with a nylon seal. (4) MF mineral glass with a stepped nylon seal. This gives more clearance between the hands and the glass.

MINERAL GLASS

The second type of glass is known as mineral glass. These are normally flat, round pieces of glass, and there are also two variants: the first is simply glued into the bezel, while the second has an i-gasket. This is a nylon-type synthetic washer which fits into the bezel groove first, and the glass is fitted over it, providing a watertight seal. The i-gasket tends to be 0.1mm larger than the bezel groove, and is now the most commonly used type of glass in the watchmaking world.

Mineral glasses are fitted in a similar fashion to UB glasses. First the gasket is fitted into the case. Look at the gasket as you are inserting it, as it has a leading edge that helps guide the glass into place. It is important that this is pointing towards where the glass is to be fitted. The case is then laid on top of a cupped or flat die in the same way as the UB, and then a flat die is used in the top of the glass press. The glass is now simply pressed into the bezel groove, with a reasonable amount of force.

39. ADJUSTING THE HAND FRICTION

Poor hand friction is caused by a loose or a tight cannon pinion, and is a fairly common fault. A tight cannon pinion may not be the most obvious of faults for a novice to recognize, the main giveaway being the tightness of the hand setting. Recognizing this is something that will come with time, as you work on more and more watches. A loose cannon pinion, on the other hand, is easy to spot because the hands will move back and forth at will with the slightest knock on the case. Loose hand friction will also give the impression that the watch has suddenly lost or gained time, or it may even cause it to stop. The second clue would be felt during hand setting, because there will be almost no resistance when the winding crown is turned to set the time. A very tight cannon pinion (stiff hand friction) can obviously be felt.

The short-term consequence might be that the centre wheel's extended arbor snaps off inside the cannon pinion, although this would be a fairly rare occurrence. Normally it is fairly obvious that the cannon pinion is just a bit too tight, but it is not easily felt as the winding stem does not drive the cannon pinion directly. You can, however, see it quite easily on an older-style watch that has no hack piece (also known as a 'balance stop', a lever that stops the watch when the owner puts the watch in hand set). Thus when you turn the hand backwards, if the hand friction is just right you should be able to slowly bring the watch to a stop. However, if you can bring the watch to an immediate stop, then the hand friction is too tight. But if it fails to affect the seconds hand, then the hand friction is too soft.

A reason for the friction being too hard may be poor lubrication, or possibly a worn cannon pinion.

ADJUSTING SOFT HAND FRICTION

To tighten a cannon pinion, you must tighten the screws inside it, and there are several tools for this job. The most common type has a 'V'-shaped block: the middle of the cannon pinion's waisted section sits in this, and its dent lines up with a wedge-shaped punch, somewhat reminiscent of a guillotine. Some jewelling tools and staking sets will have an anvil and punch that work in a similar fashion.

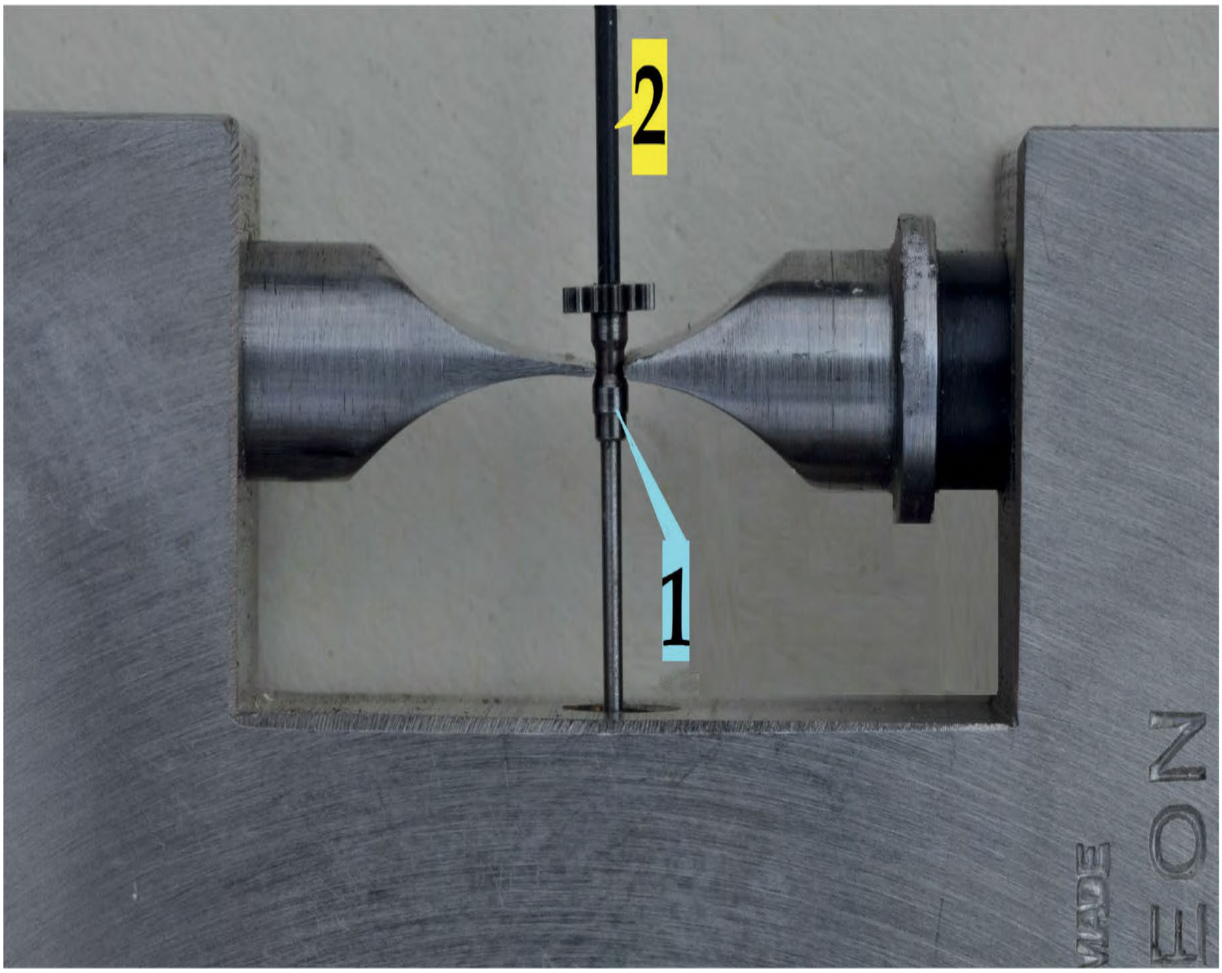


Fig. 262: Tightening a cannon pinion with the Bergeon's cannon pinion tightener. (1) Cannon pinion. (2) Tapered steel wire, or a watch-/clockmaker's smoothing brooch will do.

First, you will have to insert a smoothing brooch or some other tapered piece of metal inside the cannon pinion. This is to prevent the cannon pinion from being crushed when the dent is struck with the punch, which itself is hit with a watchmaker's hammer.

ADJUSTING TIGHT HAND FRICTION

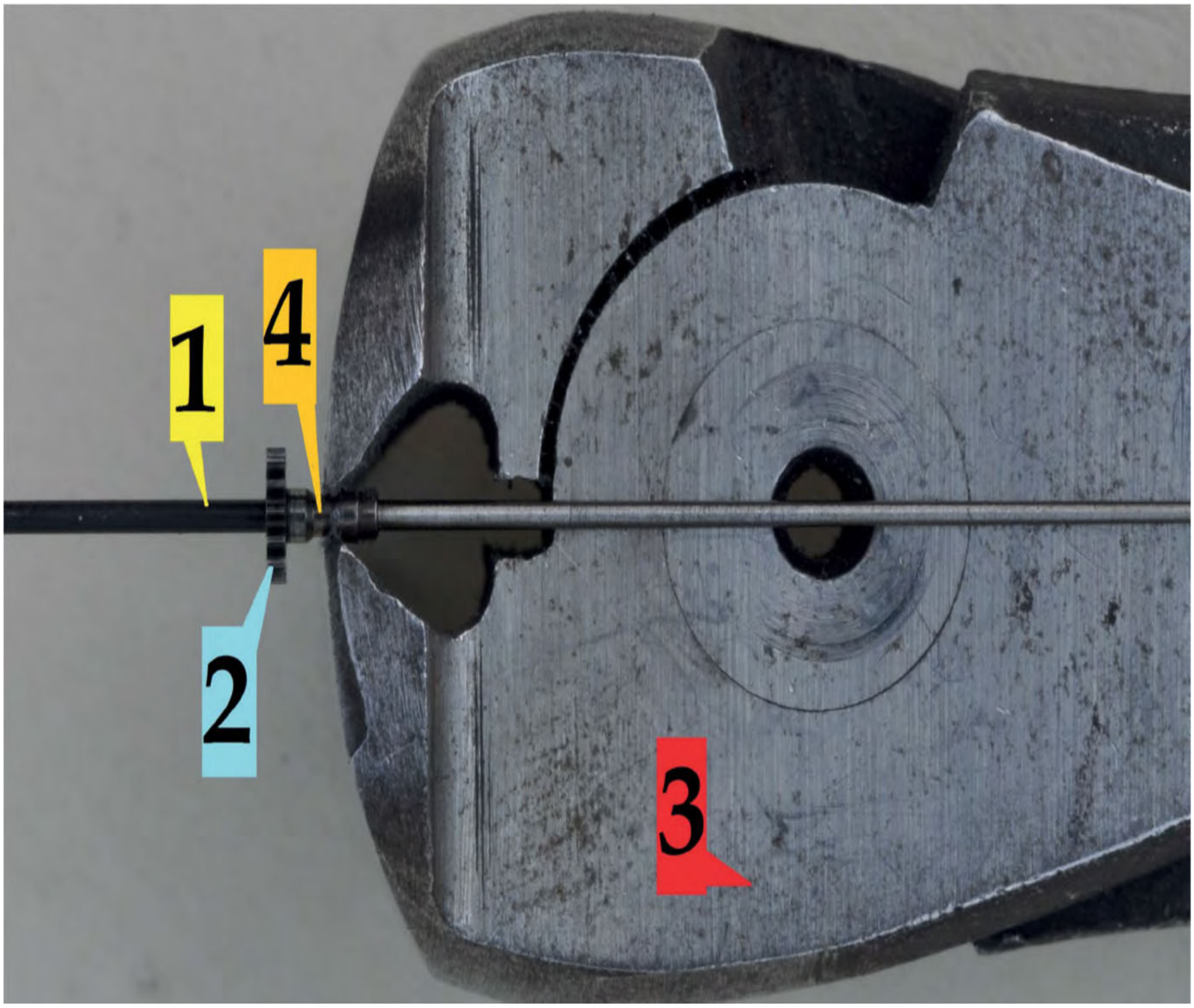


Fig. 263: Tightening a cannon pinion with slightly blunt cutters (3). (1) Watchmaker's brooch or tapered wire. (2) Cannon pinion. (4) Dent in the cannon pinion that provides the friction.

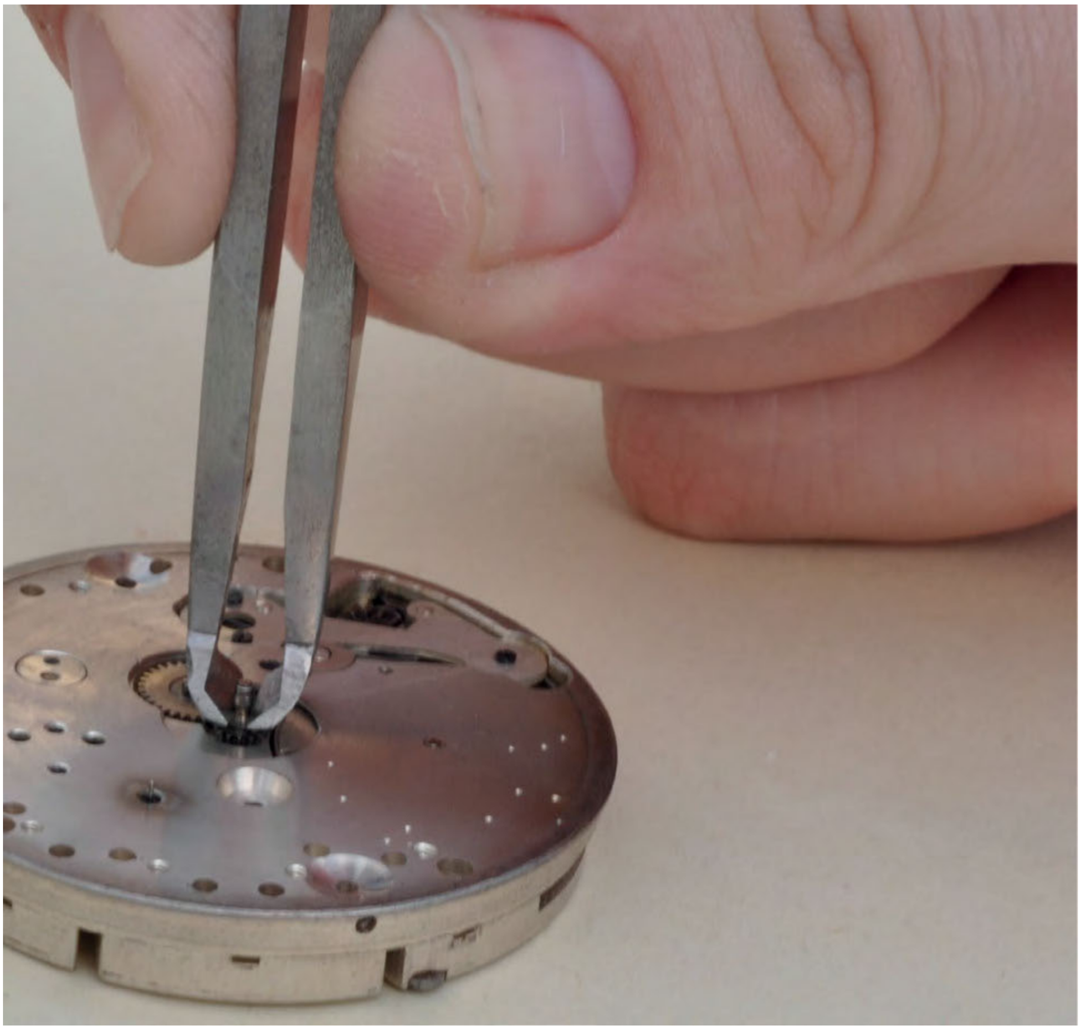


Fig. 264: Using old cutting tweezers (see Fig. 7 (7: 15a)) to slacken off the hand friction.

To loosen a cannon pinion you must squeeze its waisted section 45 degrees from the dent, and rotate it.

40. REPLACING LUMINOUS PAINT

Warning: Some of the substances discussed below are hazardous to health if inhaled, therefore I would highly recommend that you use both a face mask and gloves when handling them. Work is work, and play is play, but you have only one body, and I'd like to think that you keep it in good shape for as long as possible.

LUMINOUS COMPOUNDS

There are three main types of luminous compound: micro gas-lights, tritium paint and radium-based paint.

Micro Gas-lights

These are tiny self-powered micro gas-light tubes that safely capture tritium gas. The inside is coated with luminescent material, such as phosphorus, which is totally safe to both us and the environment. Micro gas-lights require no external light source to charge the paint in order to make it glow, and unlike the alternatives it has quite a long life of twenty-five years before it loses its glow.

Tritium Paint

This is the most common type of paint used. It is a radioactive compound (emitting beta radiation, which cannot penetrate human skin), but is active at only very tiny levels and as no more than background radiation. Widely used by manufacturers from the late twentieth century to the present day, it has a radioactive half-life of twelve and a half years, so after that, luminous watch hands will be half as bright as they were originally. Typically they must be replaced sometime between fifteen and twenty-five years. The paint also has to be charged in the light in order for it to work, and it only glows for ten to thirty minutes.

Radium: Radium-based paints were the first to be used on watches. The paint is a combination of radium, which is quite radioactive, and zinc sulphide, and the zinc sulphide reacts with the radiation from the radium, making it glow. It has a radioactive half-life of something like 1,500 years, and the glowing properties of the paint last for around fifty years. Ultimately the zinc sulphide is decayed by the radiation, and slowly diminishes to a dim glow thereafter. It will glow really brightly without the need for charging in daylight.

This paint was first applied to watch dials and hands around the time of World War I, and was widely used on aircraft instruments and timepieces, recognizable by its normal yellowish-brown colour. The leaf-green variety is more commonly seen in watches from the 1940s and 1950s.

The amount of radiation given off by radium-based paint is only slightly higher than background radiation, and only a large quantity of old luminous hands can be dangerous. If you wish to keep such hands for future restoration projects, they need to be stored in an airtight lead box about 1cm thick. If you are concerned about their radiation levels you could always go to your local school and ask their science department to wave their Geiger counter over them.

Alternatively, if you are thinking of working with old watches, it might be advisable to buy a Geiger counter from the internet. They are not as expensive as you might think.

REPLACING LUMINOUS PAINT IN WATCH HANDS

Preparation

First remove the hands from the watch and clean out the old luminous material using a sharpened piece of peg wood, being careful not to mark them while scraping off the residual paint.

Tip: Stopping a minute to think again about health and safety, I would highly recommend using a container with a small amount of water to just cover the hands to prevent inhalation of any radioactive dust, as traditionally the paint is normally radium or tritium based.

This is also a good time to remove any heavy corrosion on the surface of the hands: use a glass scratch brush or micro paper, or a fingernail polishing stick – the type with various grits also works well. If the hands are only lightly corroded and require only a light polish, use a leather buff stick charged with a small amount of jeweller’s rouge, watchmaker’s diamantine or chrome polish (Autosol from a car shop); this will also remove any fine scratches on the front of the hands.

Tip: When you buy jeweller’s rouge, buy it in powder form and mix it with a small amount of methylated spirit. Jeweller’s rouge is best used on gold or brass watch hands. Bergeon’s diamantine also comes in a powder form, and needs to be mixed with olive oil to make it the consistency of runny toothpaste before you use it. This is best used for a high mirror black polish on steel hands.

When using a polishing compound be aware that the more you use, the more it cuts (the more it removes scratches), and it is only when it starts to dry out that it starts to burnish the surface. This is the time to stop and admire your handiwork, so remember to use such products sparingly.

Warning: When polishing watch hands, work the leather buff stick in a small circular motion, never back and forth. The hands will bend, as they are very thin!

RE-BLUEING THE HANDS

The majority of old steel watch hands are blued. If you have cleaned your watch hands and they are now a silver colour, you will need to re-blue them. First you must clean them in a degreaser or in alcohol. Next, place them on a piece of scrap sheet steel or brass, or on an old steel ruler, or even an old, worn large penny. Holding the makeshift metal heating ‘plate’ in some pliers, heat the bottom with a small gas torch or a traditional watchmaker’s meths lamp. Alternatively you could set the hands on a pile of brass shavings in a tin and heat the underside of the tin.

Waft the ‘plate’ over the flame, as you only wish to heat the hands slowly. You will be able to observe them change colour from yellow to brown, to purple and finally to blue. When they just start to change from purple to blue, remove them from the flame and leave them to cool. The desired colour is a deep sapphire blue with a hint of purple. When the colour changes from blue to the next colour, this happens very quickly, and if you are slow to take them off the heat, the colour will quickly change to a silver grey. If this happens, you will have to re-polish them and repeat the process.

APPLYING LUMINOUS PAINT

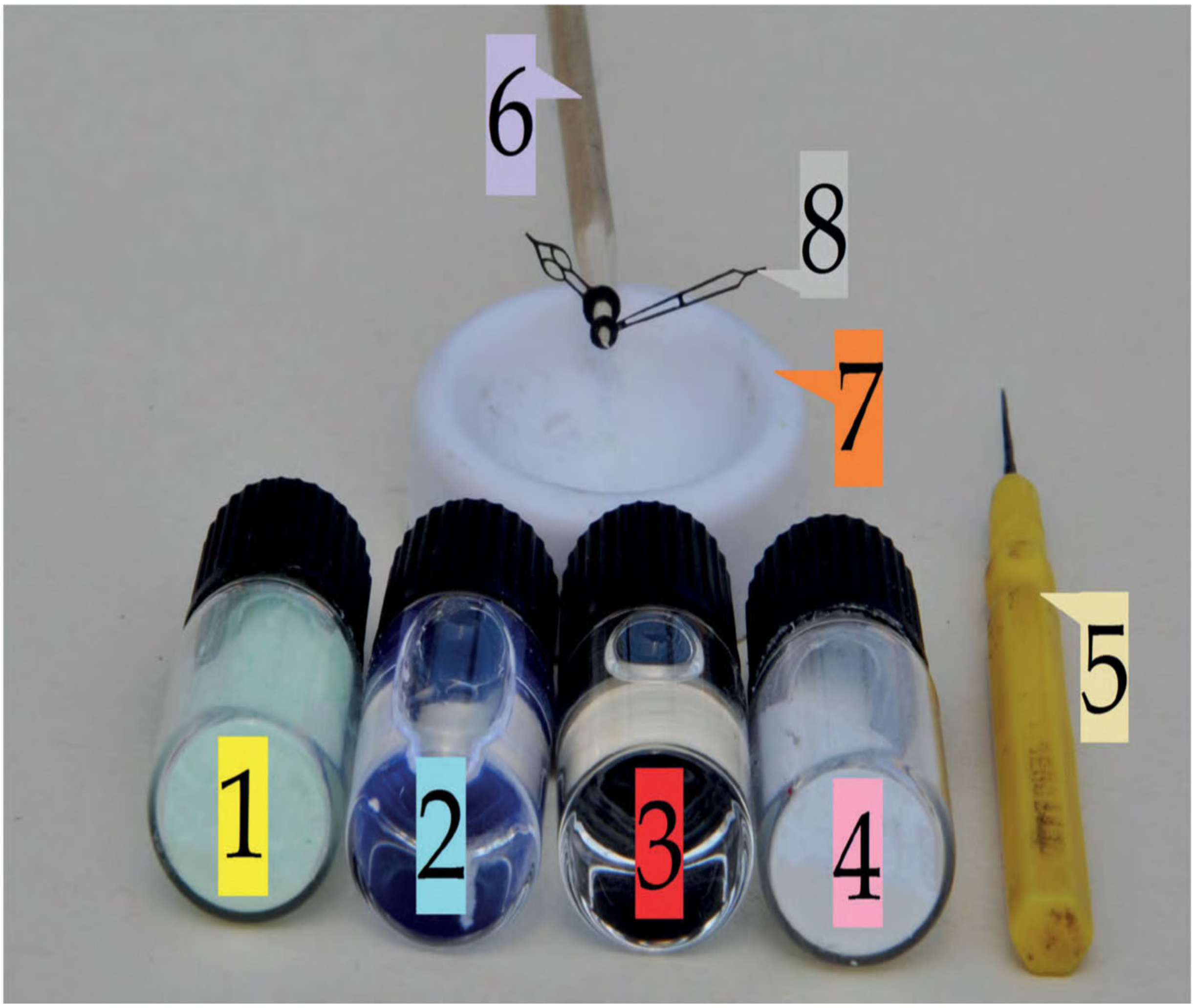


Fig. 265: Bergeon's luminous tritium paint. (1) Light green luminous powder. (2) Gel. (3) Thinners. (4) Light yellow luminous powder. (5) Yellow oiler. (6) Peg wood. (7) Mixing pot. (8) Hands in need of repainting.

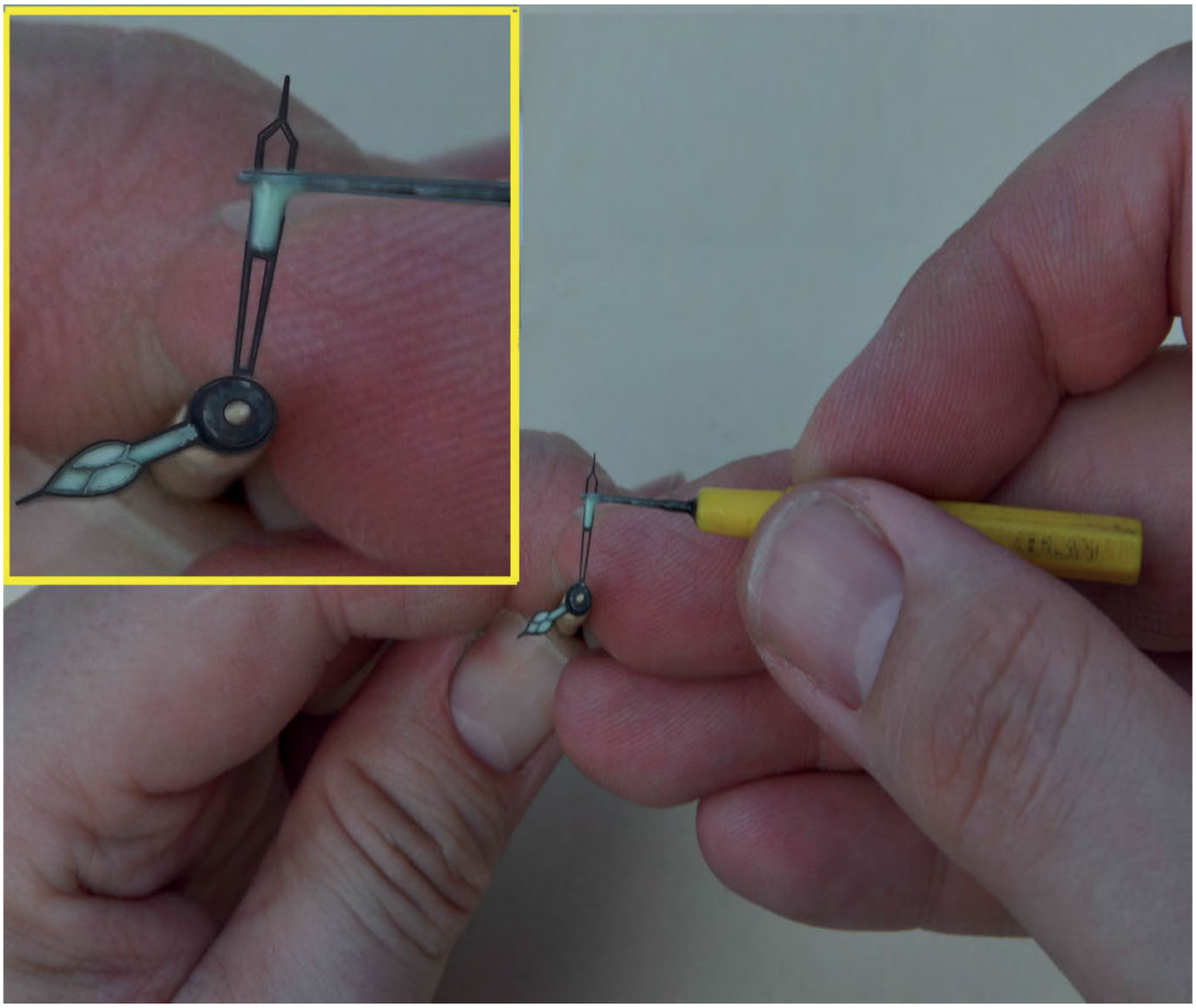


Fig. 266: Applying the paint.

To be able to do this job neatly, we will need to hold the hands. Use some peg wood whittled down to a long tapered point (or a cocktail stick will do), and push both the hour and the minute hands on to the peg wood to a tight fit. Then displace them, so that when you look at them, they show ten past ten: like this, once they are newly painted, you will be able to lay them down on the bench to dry without spoiling them.

Next you will have to mix the paint. I prefer to use Bergeon's luminous tritium paint. This comes in three parts: dry luminous powder (which comes in several colours), gel and a thinner. Mix the luminous powder with the gel, a small amount at a time, until all the powder has been mixed into a thick paste. Add a small amount of the thinner, until it resembles gloss paint.

To apply the paint to the hands you will need a large watch oiler. Dip the oiler into the paint and then, in a smooth motion, draw the paint across the back of the hand from bottom to top (or top to bottom, whichever you prefer).The paint will form a film across the back of the hand, almost like a coloured bubble. If you managed to get the consistency of the paint right, you will only require one coat. You must take care not to apply too much paint, as this may cause the hand to catch, due to the lack of clearance caused by the thick paint. If this is the case you can use a little emery paper on the paint once it is dry.

Tip: If you require an antique finish to the paint, drop a few granules of dry brown or black powder paint into the already mixed luminous paint, and mix it very lightly to cause a marbling affect; then apply it to the hands. Alternatively if you require a colour that is not available, use the white or yellow luminous powder mix as normal, and add powder/oil paint to the mix to colour it. If you wish to replace the luminous dots on a dial, just mix the paint a little thicker so that when you pick some up and touch the dial you will deposit a small round blob on its surface.

PART V: DIFFERENT TYPES OF WATCH MECHANISM

41. ALTERNATIVE HAND FRICTIONS IN WATCHES

CANNON WHEEL

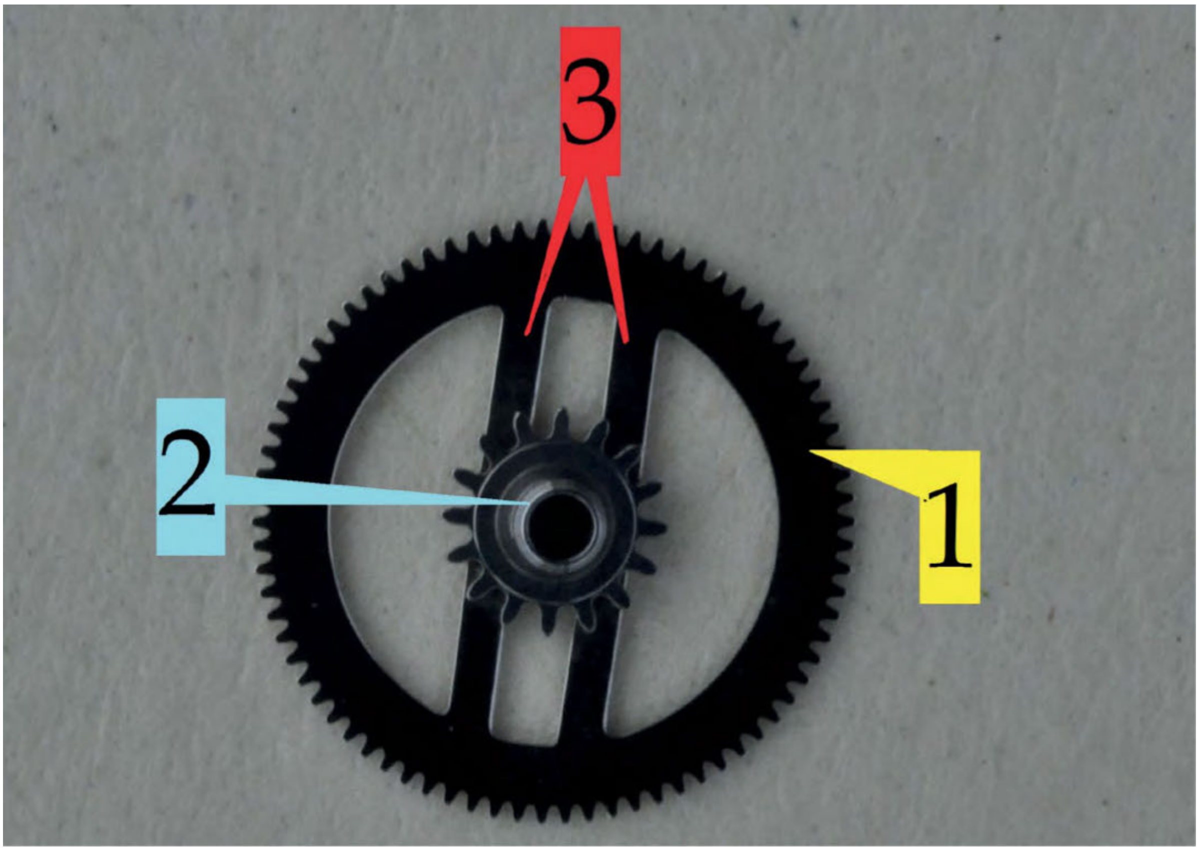


Fig. 267: (1) Cannon wheel. (2) Cannon pinion. (3) Two friction springs.

This is a fairly modern invention in the world of horology and has been widely adopted by most manufacturers for watches that have a centre seconds hand.

In a watch with a cannon wheel, the centre wheel (now called the second wheel) has been offset from its normal centred position, and the third wheel (now called the centre seconds wheel) has been placed in the centre. This gives us our centre seconds, but nothing to drive the hour and minute hand in the middle of the watch: hence the cannon wheel. This wheel is made up of two separate components: the drive wheel with two friction springs (spokes) at its centre; and the cannon pinion which is held captive at the centre of this wheel at its base by two friction springs, which snap into a little groove on the cannon pinion's base. As the two springs are now pressing on the side of the groove, they provide the hand friction (with the aid of some lubrication to prevent seizing).

The cannon wheel slides over the support tube of the centre seconds wheel, but unlike a cannon pinion in this position, this is not a friction fit on the tube and it floats here freely. The cannon wheel's drive wheel then meshes with a pinion on the second wheel (formally known as the centre wheel).

When the watch is in hand set, the cannon pinion rotates normally with the same torque as you would expect. The cannon-pinion drive wheel remains stationary, leaving the gear train unaffected.

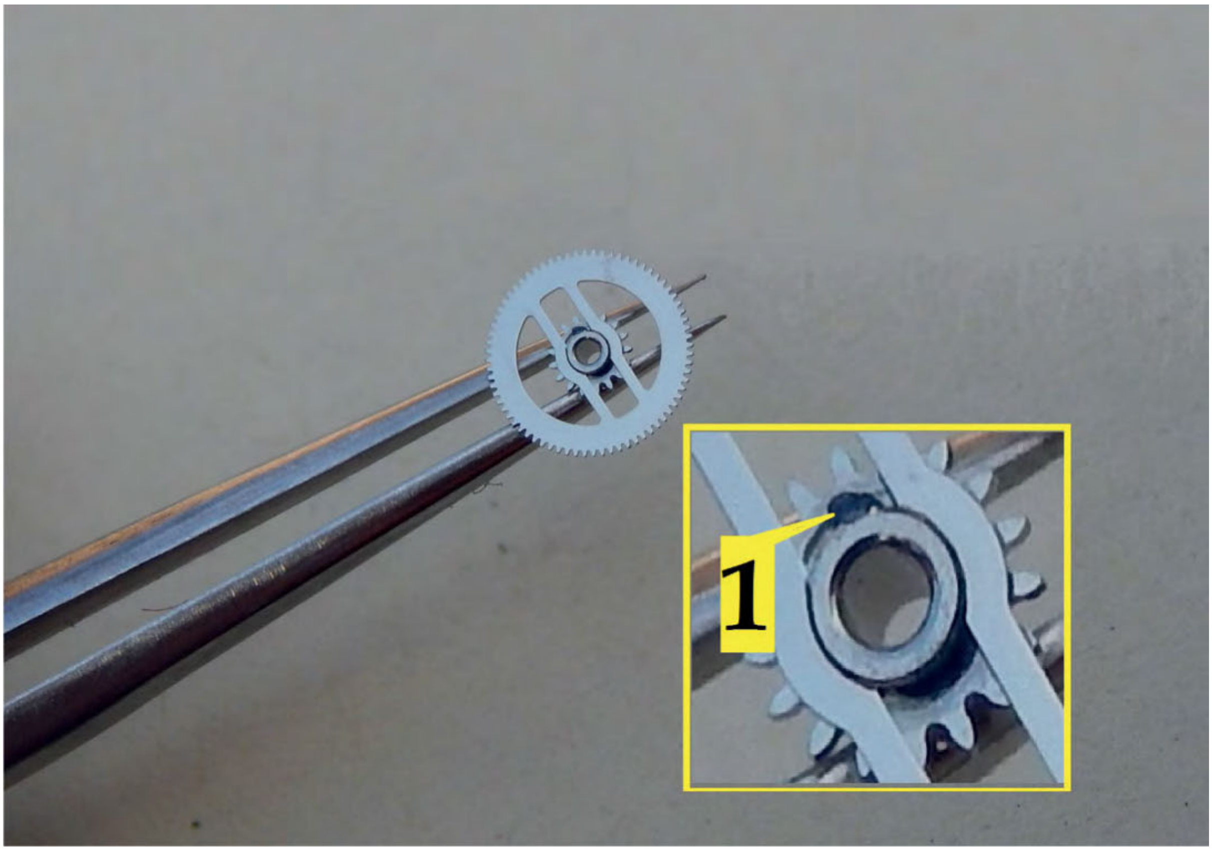


Fig. 268: Lubrication of a cannon wheel.

ANTIQUE HAND FRICTION WITH HOLLOW PINION

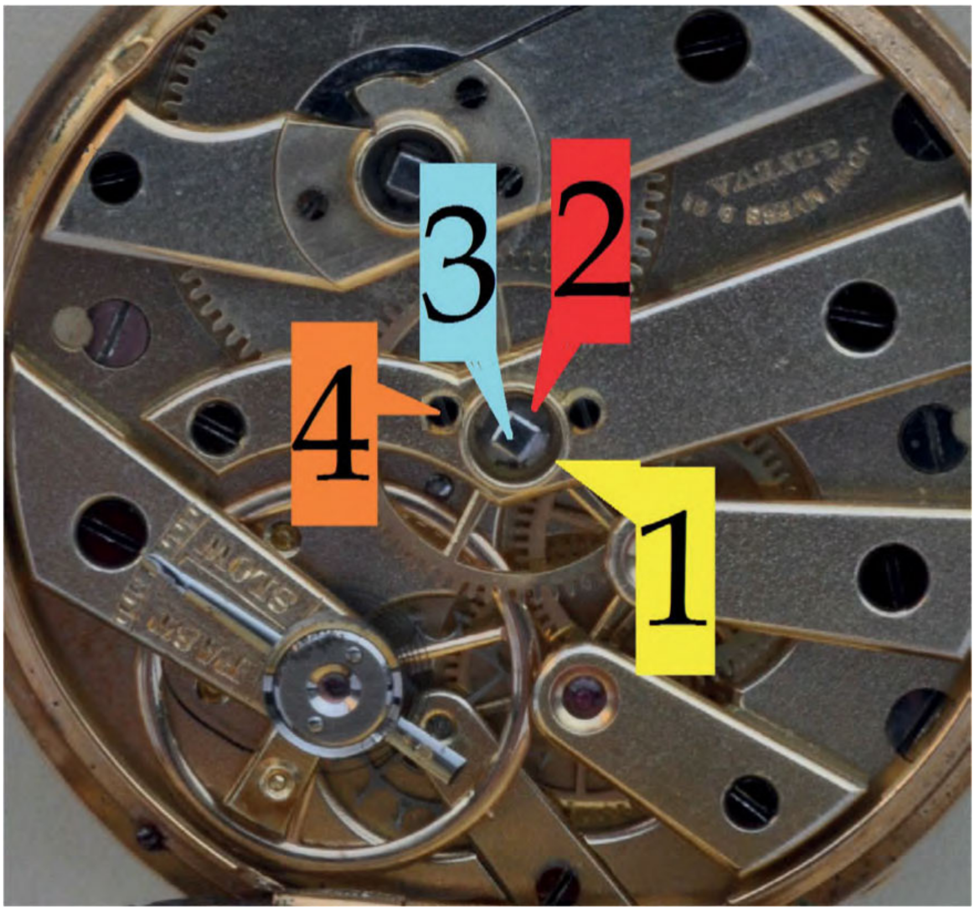
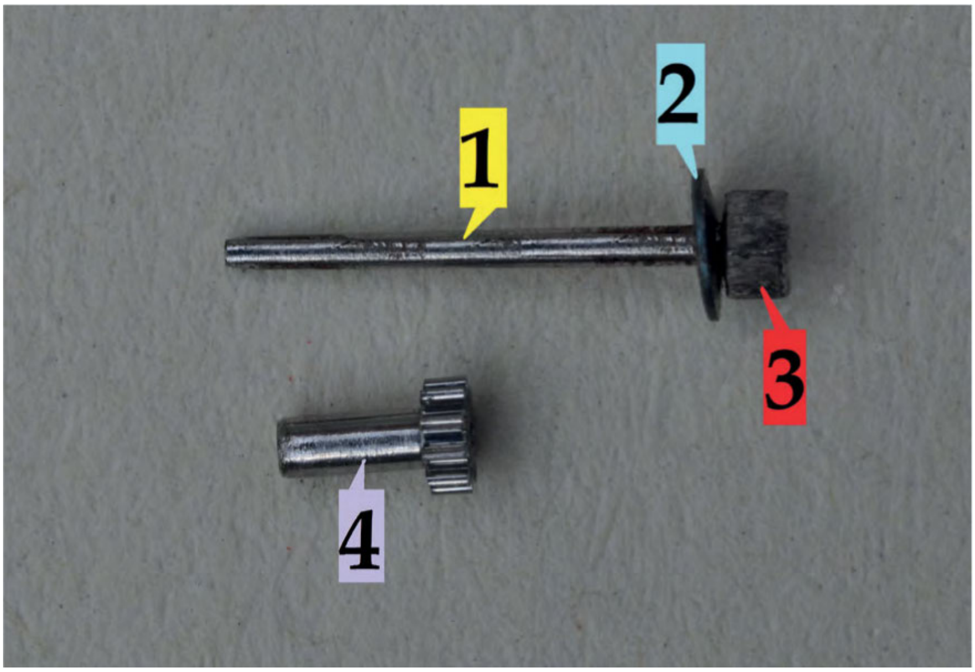


Fig. 269: Antique hand friction with hollow pinion. (1) Dustcover. (2) Washer used as a dustcover to protect the centre wheel pivot from dirt. (3) Hand-setting arbor with square. (4) Dustcover securing screws.

This type of hand friction is normally found in pocket watches from the late nineteenth century, typically of the bar-type movement and occasionally found in early pin-set wristwatches. This system is a throwback from key-set pocket watches, where you would have a drilled-out centre wheel arbor. This centre wheel has an arbor that finishes just short of the main plate. To clarify, the centre wheel has two pivots the same length, unlike a modern centre wheel where you have an extended pivot on one end, which the cannon pinion snaps on to.

A second arbor, with a rounded end resembling a dressmaker's pin, passes through the centre of the drilled centre wheel arbor from the back plate of the movement, and extends beyond the main plate. This second arbor is a snug friction fit in the hole, and has lubrication on its surface to prevent the second arbor from seizing inside the centre wheel arbor. A cannon pinion is then driven on to the extended end of the second arbor in a similar fashion to that of a modern cannon pinion. Unlike modern cannon pinions, this cannon pinion and arbor rotate as one during hand-setting. The hand friction is not coming from the cannon pinion, but from the second arbor inside the centre wheel arbor.

There are three differences with this cannon pinion: there is no undercut on the arbor; there is no waisted section on the cannon pinions; and there is no lubrication inside the cannon pinion.



Removal of the Cannon Pinion and Arbor

Fig. 270: (1) Removed hand-setting arbor. (2) Washer used as a dustcover to protect the centre wheel pivot from dirt. (3) Square on which the key fits. (4) Cannon pinion.

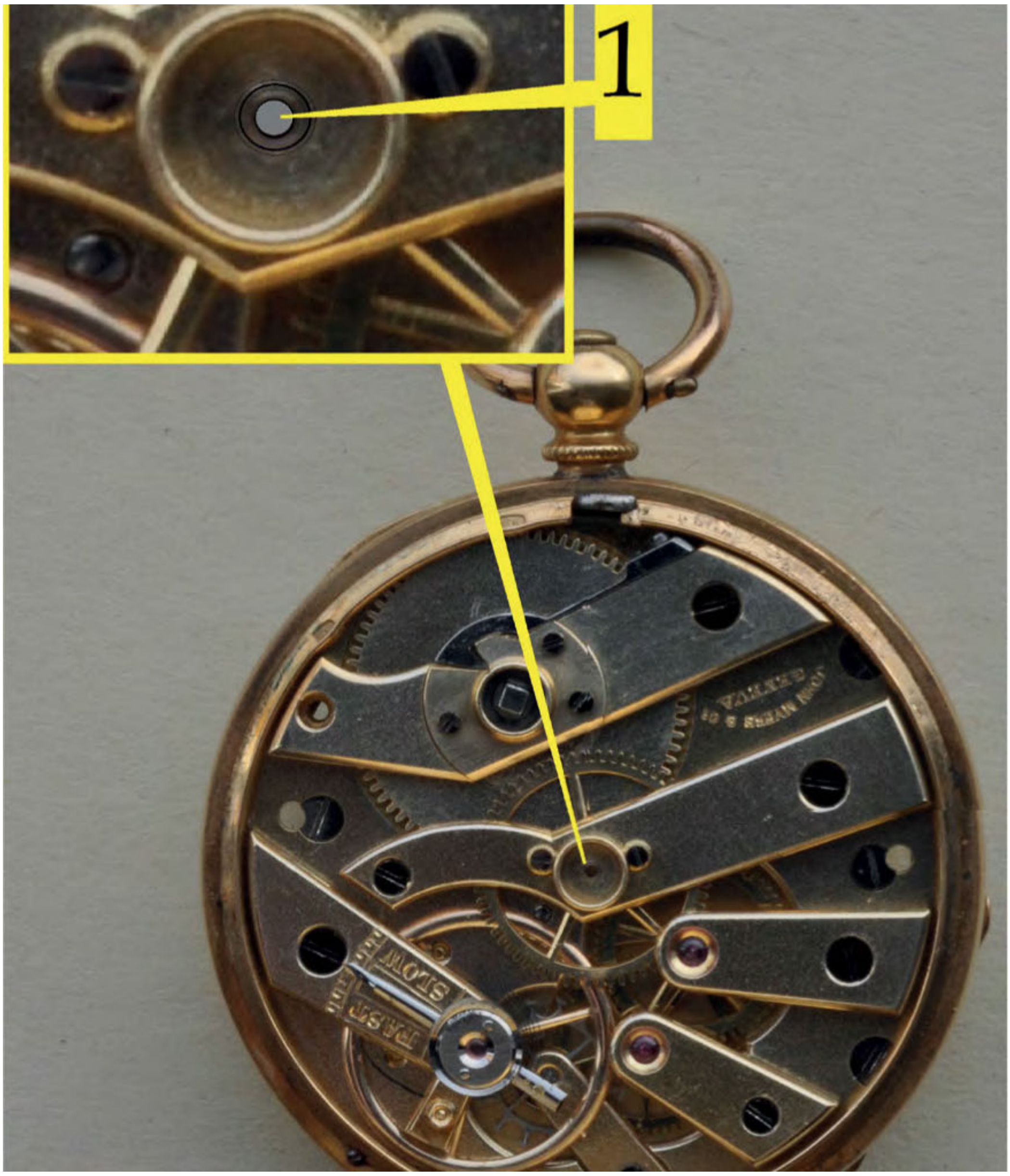


Fig. 271: The hole through which the hand-setting arbor passes.

This type of hand friction can be recognized with a keen eye once the hands have been removed, as you should quite clearly see a nipple on top of the cannon pinion, and it is this that the hand pushes on to (not the cannon pinion itself).

The following method is the one that I use regularly with great success when removing this type of cannon pinion (there is a second method, but this will require a staking set or a watchmakers’ staking block and a flat pin punch). Read through my description, and if you wish to use a staking set I think you will get the general idea for removal, whichever way you choose.

First, you absolutely *must* let the power off the mainspring before removing the balance wheel from the watch; then remove the balance wheel.

Lay your tweezers flat on the bench in front of you, with the cannon pinion facing the bench, and the extended part of the arbor on the flat end of your tweezers just above where the logo on your tweezers is normally engraved.

Hold the movement with both hands, with the cannon arbor resting on the end of your tweezers, and position the movement level with the worktop. Apply a small amount of downward pressure, and you should hear a small click: the cannon pinion end of the arbor should have moved further inside the cannon pinion. If you look at the back of the movement the arbor should now be protruding out of the movement.

You should now be able to remove the cannon pinion with your pin vice, in the same way as a regular cannon pinion. If you still struggle, you can place the movement in a holder with the cannon pinion facing the worktop.

With the flat end of your tweezers, push the centre wheel arbor back into the movement, then turn the watch over and lay it flat on the worktop. If you look at the cannon pinion it should now have lifted up away from the main plate. This will give you enough room to be able to use a pair of hand levers to lift off the cannon pinion from the arbor. Alternatively, you could use your presto hand removers in the same fashion.

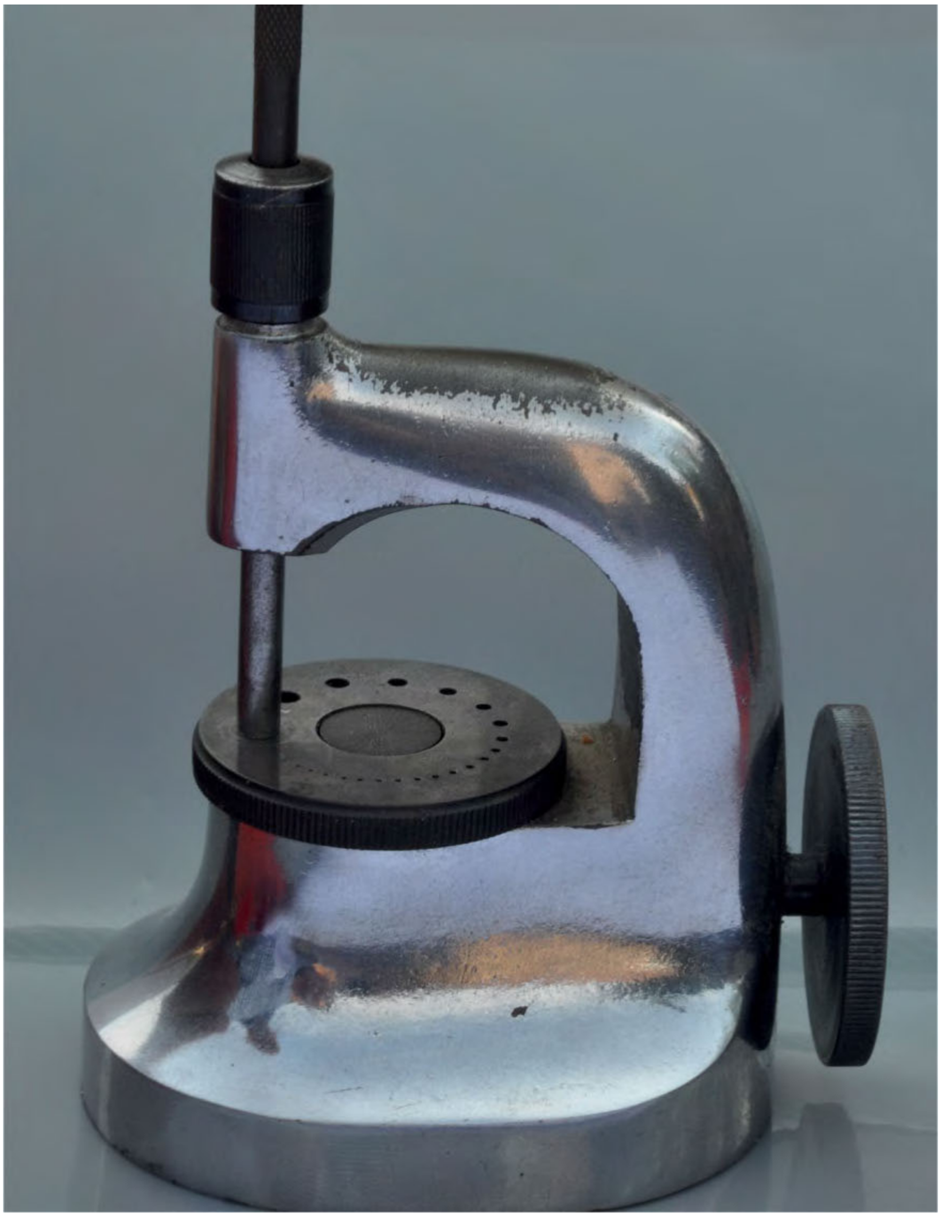


Fig. 272: Watch repairer’s staking tool.

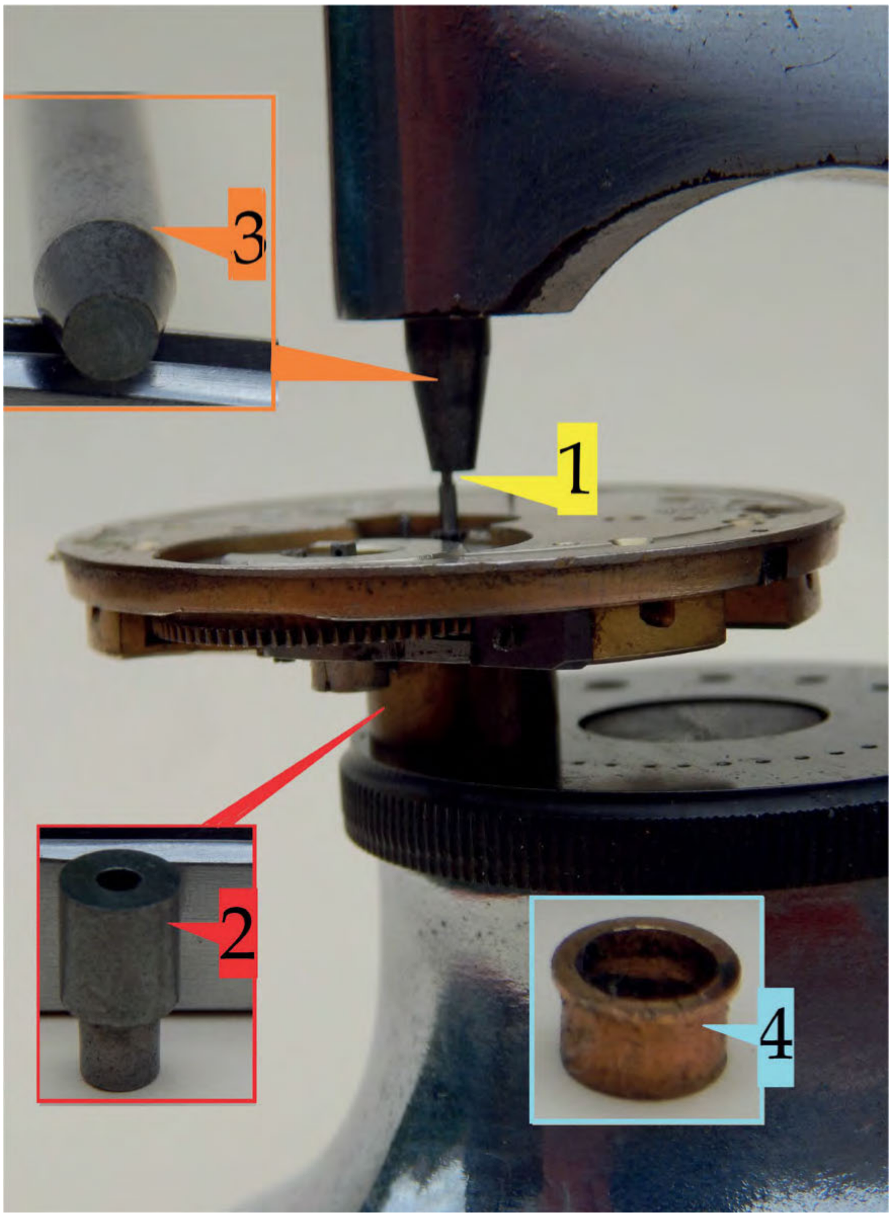


Fig. 273: Removal of the arbor. (1) End of the hand-setting arbor that rises just above the cannon pinion. (2) Anvil used. (3) Flat punch used. (4) Remember to remove the dustcover if your watch has one.

OFFSET CANNON PINION

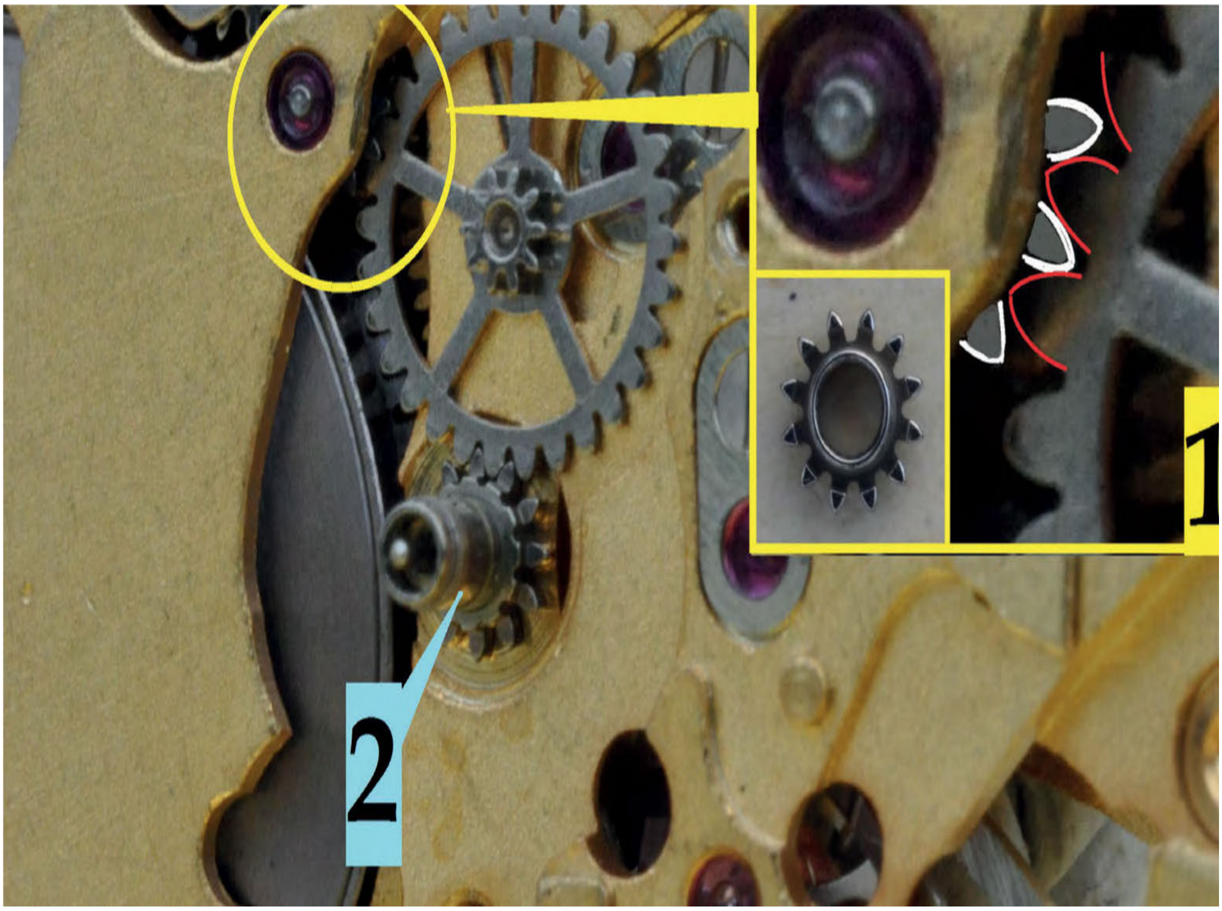


Fig. 274: Offset cannon pinion. (1) Second or intermediate wheel cannon pinion. (2) Dummy cannon pinion.

This is one that always catches out a keen student: they have lovingly cleaned their watch, put it all back together and it is ticking away nicely, only to find that they cannot set the hands! This type of watch is normally from the 1960s or 1970s and has a centre seconds hand. The big giveaway should be the fact that the cannon pinion will probably lift off with the hour wheel, or you will feel no resistance when you remove the cannon pinion.

The second clue is that there will be a little spring that will press on the minute wheel's bottom pivot, mounted in the base plate. This is needed to stop the hands from flapping about with the extra backlash caused by this design (non-direct drive – explained later). Without a dampening spring this could make the hand move plus or minus five minutes when being worn.

The third clue is to look around the radius of the minute wheel, and you should see a pinion that is raised up above the movement in the area of the barrel. It should rotate during hand set when being driven by the minute wheel. This pinion is a small dumpy cannon pinion mounted on the second wheel, normally known as the centre wheel, but as this watch has the fourth wheel in the centre, the centre wheel (or now the second wheel) has been offset, along with the cannon pinion. The watch does have a cannon pinion in the centre, which is a dummy cannon pinion.

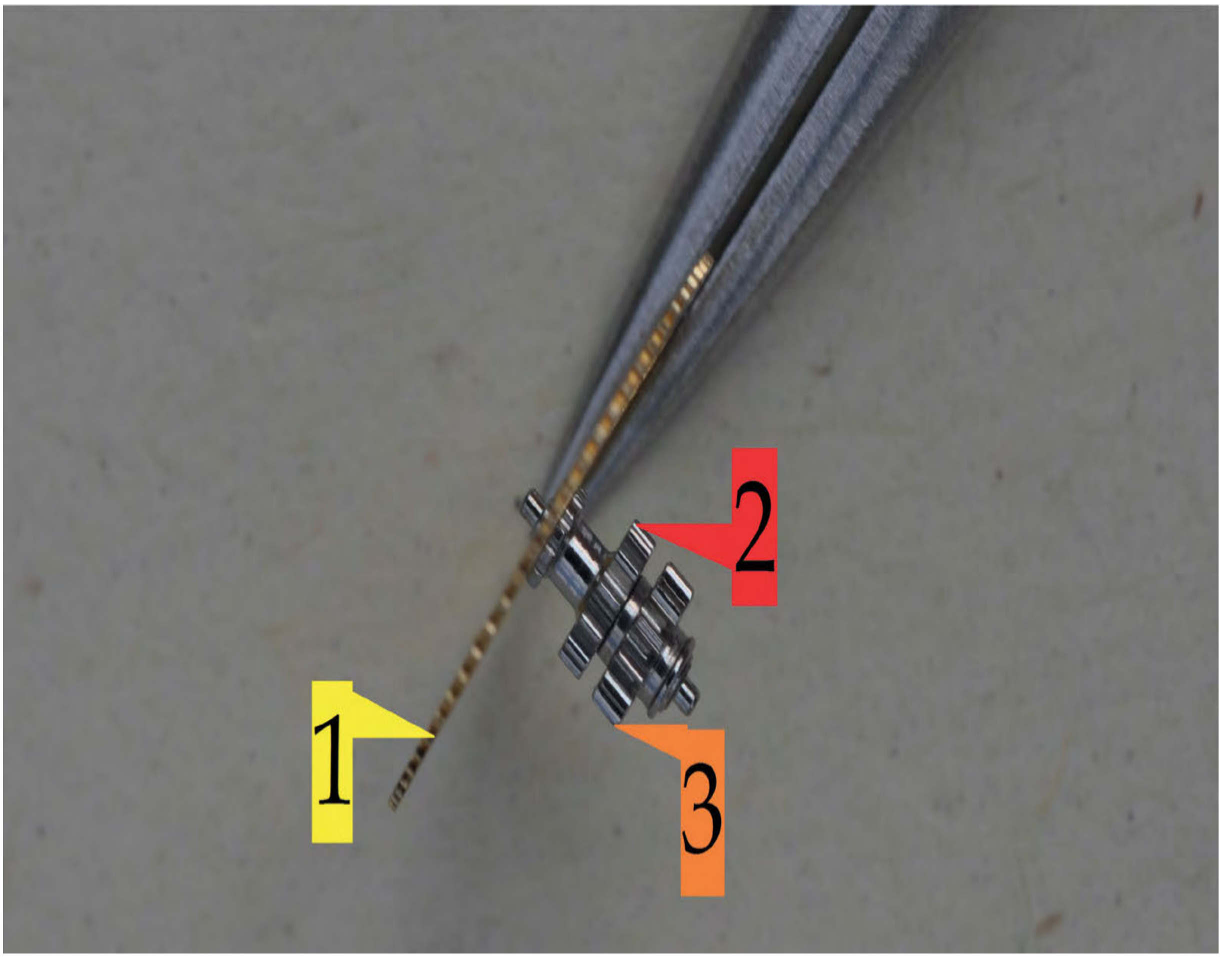


Fig. 275: (1) Second wheel. (2) Second wheel pinion. (3) Second wheel cannon pinion.

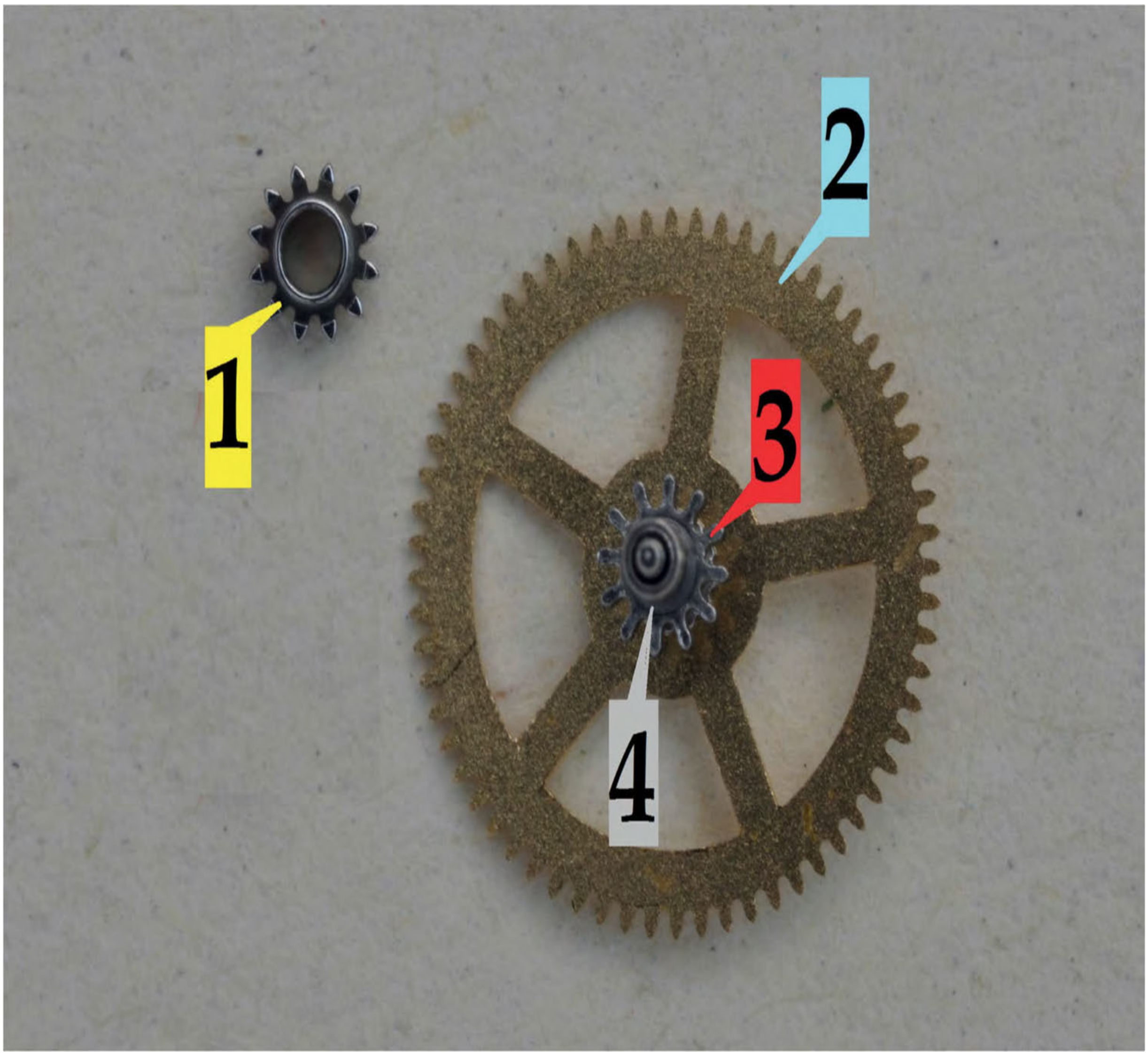


Fig. 276: (1) Second wheel cannon pinion (removed). (2) Second wheel. (3) Second wheel pinion. (4) Second wheel arbor.

Removal of the Cannon Pinion

Cannon pinions are not very easy to remove, as I suspect that they were meant to be replaced during servicing. My method is similar to that of removing the antique cannon pinion and arbor. Lay an old pair of tweezers on the bench in front of you. Take a second pair of tweezers and grab the second wheel by its arbor between both of its pinions. Rest the pivot above the cannon pinion in the end of the tweezers in front of you, making sure the wheel is level with the worktop. Apply a reasonable amount of downward pressure, as this type of cannon pinion is quite often very tight. If all is OK, you should hear a positive click.

This will not completely remove the cannon pinion, but will partially remove it. To finish the job, you will have to push your tweezer tips in the space created between the two pinions, squeeze on your tweezers and carefully lever off the cannon pinion (throughout the process taking care not to pull the wheel off the arbor).

Tip: Take a picture of the cannon pinion on the second wheel before you remove it, to avoid refitting it upside-down later on.

To refit the cannon pinion you must first apply a small amount of heavy oil to the part of the arbor the cannon pinion is to be fitted into. Refitting is similar to removal: rest the short pivot of the second wheel on the flat end of your tweezers or a flat metal surface, keeping the wheel level with the worktop. Place the cannon pinion back on its arbor. Taking a second set of tweezers, use the tips to push the cannon pinion home. You should hear and feel a little click. Alternatively, if you have a staking set this will do as well, now that you have the general idea.

42. OTHER TYPES OF KEYLESS WORK

ROCKING BAR

This is quite a simple idea and is a relatively trouble-free mechanism as most watches fitted with this style of keyless work rarely suffer with problems, unless afflicted with a bad repairer.

How It Works

In the winding position, the following happens when you turn the winding crown in a clockwise direction: as the winding pinion rotates, it engages with the larger steel wheel in the centre of the rocking bar plate. The two gears work at right angles to each other (similar to an old-fashioned hand drill).The larger wheel then drives the two mating gears either side of it, and they both run on posts fixed to the rocking bar. Note that the two smaller gears rotate in the opposite direction to the larger gear, and the two smaller gears rotate on posts fixed to the rocking plate. The smaller gear on the left directly drives the ratchet wheel. In a nutshell, as you turn the winding crown clockwise the gears in the keyless work wind the ratchet wheel.

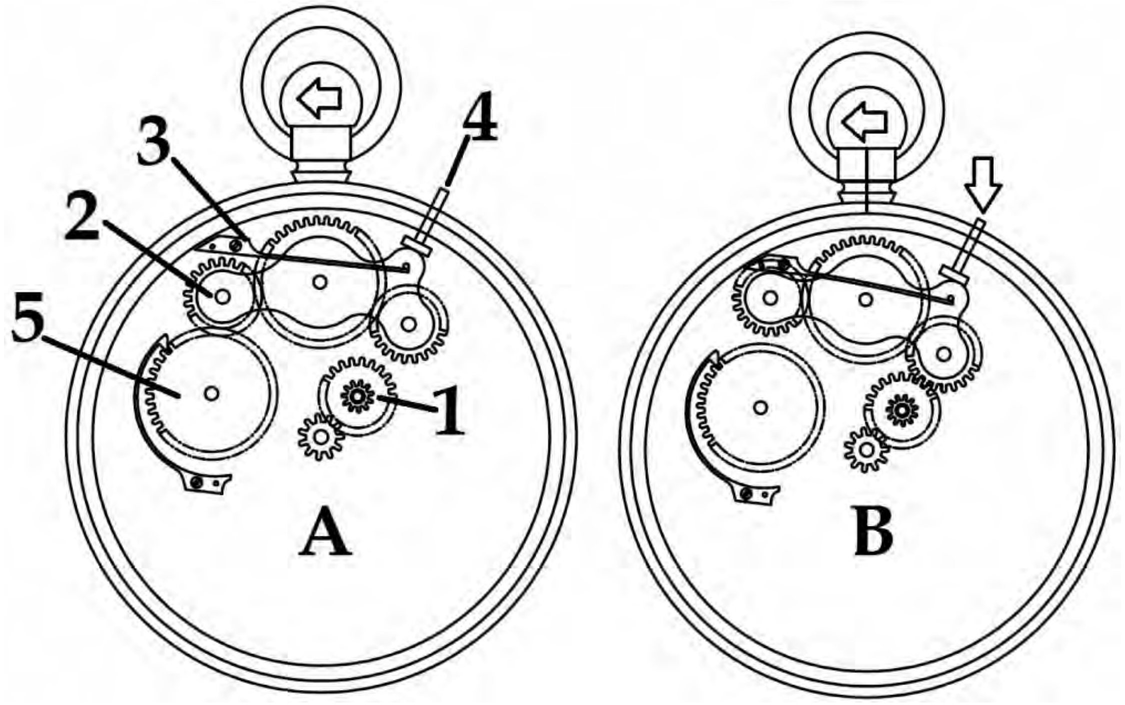


Diagram 24: Pin set keyless work. (A) Winding position. (B) Hand set. (1) Motion work. (2) Rocking-bar spring. (3) Rocking bar. (4) Setting pin. (5) Ratchet wheel.

So what happens when you turn the crown backwards? Obviously, the winding pinion turns in the opposite direction, as well as the other three gears on the rocking bar. But what happens when this transmission meets the ratchet wheel? If you think about it, the click will only allow the ratchet wheel to rotate in one direction, and that direction winds the spring in the barrel. The clever part is the fact that the rocking bar pivots in the centre, as there is a round plate holding it to the movement, hence the name rocking bar. Because the smaller pinion on the left can't turn the ratchet wheel, this causes the bar to rock as the two wheels repel each other (nothing important happens).

Hand Set

On the outside of the case positioned around one o'clock is a lump. This has a pin at its centre and a slot crossing the centre as well. You should be able to insert your left index fingernail into this slot. This depresses the pin (pusher), which pushes on the right-hand side of the rocking bar, making it rock to the right. This movement disengages it from the winding mechanism and engages it with the minute wheel, enabling the hands to be set in either direction, if you turn the winding crown with your right index finger and thumb.

NON-RECOILING CLICKS

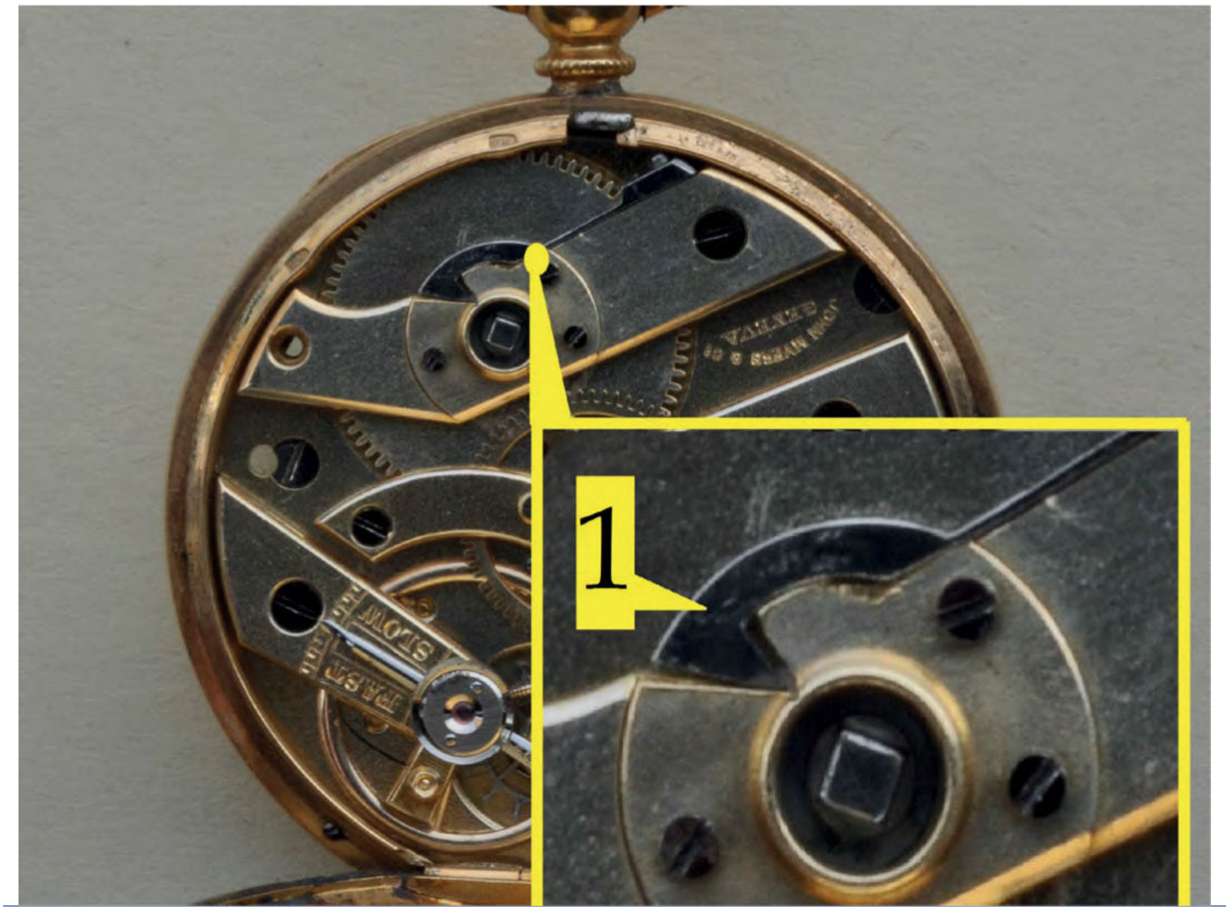


Fig. 277: Non-recoiling click found in earlier watches.

Clicks never started out like the one in your watch. Like most technology, they have evolved over time. The click in your watch has been designed to recoil slightly, an improvement made over many years of trial and error. Over time, watchmakers soon had problems with failing mainsprings due mainly to the quality of the metal used and the way in which earlier watches hooked inside the barrel. All these issues arose from similar problems experienced by clockmakers.

GENEVA STOP WORK

Early wristwatches were prone to being ‘overwound’. I use this phrase very loosely in that the owner would wind up the spring so tight the watch would pick up speed due to the increased tension on the spring and its hook. Not only would this cause bad time keeping, it would also increase the likelihood that the hook would tear and break off. One solution was to use Geneva stop work (sometimes known simply as ‘stop work’). This device could be fitted on to the barrel cap and barrel arbor of any watch (assuming there was room). The clever thing about this device is that it would utilize the middle portion of the mainspring’s power, giving a more even power distribution from the mainspring.

For example, if you wound the watch one click of the ratchet wheel, the watch would start running as there was already a three-quarter turn of power on the mainspring. But if the watch were fully wound, the Geneva stop work would stop you short of the last three-quarters of a turn on the spring. It ensures that the middle portion of the mainspring is used, as this is where the power is most constant, unlike a normal barrel, which has a lot of power when fully wound, and a lot less when it is wound down. This variation in power can cause a watch to speed up or slow down. Geneva stop work was only ever a ‘sticking plaster’ for watchmakers (even if a popular one with higher grade watches). The problem was only resolved in time with improved materials for springs, the improvement of escapements, and the introduction of the recoiling click.

Stop Work Components

There are three components to Geneva stop work:

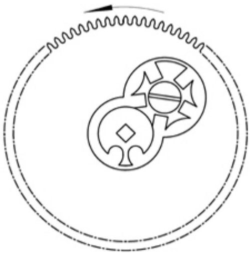
Cam or cross piece: Normally seen with four matching extensions, the ends of the protrusions of the crosses are radial at their tips. There is a notable odd extension on one protrusion, which has a reversed radial surfaced end.

Finger piece or index piece: Sadly these are normally missing from most watches, as they quite often break due to an over-keen owner winding up the watch too vigorously. Once broken, they are rarely replaced, tending to be thrown away by lazy watch repairers. This is normally due to the fact that the repairer didn’t have the necessary skill set to make a new one (or the owner is not prepared to pay the restorer to make a new one, usually due to the low value of the watch at the time of repair).The watch will happily function without the Geneva stop work, but the timekeeping will be diminished.

Shoulder screw: The middle portion of this screw is the bearing surface for the cross piece on which it rotates, and there is a thread on its lower end which screws into the barrel cap.

How It Works

During normal running of the watch the cross piece remains stationary and hovers around the radial circumference of the finger piece for one rotation of the barrel as the barrel rotates. At the end of this rotation, the finger piece of the stationary finger-piece cam, which is attached to the barrel's arbor, enters one of the slots in the cross piece. As the barrel continues to rotate, the cross cam is indexed by one division. This action will repeat four times until, on the fifth time, the cam will fail to index. Instead it will collide with the reversed radial end of the cross piece. This ultimately stops the watch and prevents it from using the last three-quarter turn of the spring.



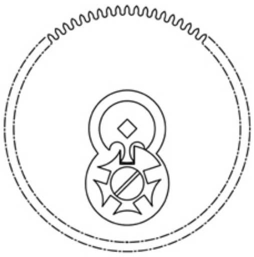


Diagram 25: Stop-work during unwinding.

Diagram 26: Stop-work unwound.

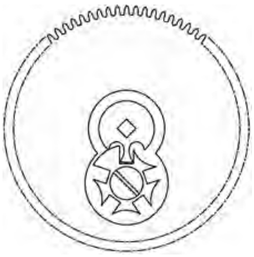


Diagram 27 Stop-work fully wound.

During winding, the finger piece, being fixed to the barrel arbor, will rotate with the arbor as the watch is wound. As it rotates (in the opposite direction), its finger piece will again index the cross piece four times until, on the fifth rotation, the cross piece and finger piece will lock up on the reversed radial end of the cross piece, to ultimately stop the owner from winding the watch, and thus prevent the watch from using the last three-quarters of a turn of the spring.

To find out if a watch has Geneva stop work, normally you will first have to remove the dial. You should soon see that there is an inspection hole to view the Geneva stop work located where the barrel is situated. If you are really lucky the Geneva stop work will be located on the top of the barrel.

Removing the Geneva Stop Work

With a key-wound watch, first remove the ratchet wheel dustcover around the winding square, which will be secured by two or three screws. Proceed to fix a pin vice to the end of the winding square.

Next, in order to rotate the pin vice by one degree, which will free the end of the click from the root of the ratchet wheel's teeth, pull the click clear of the tips of the teeth of the ratchet wheel. Take care when doing this not to pull back too far, as this may end up snapping the click and spring. Slowly loosen your grip on the pin vice to let down the power of the mainspring.

Remove the pin vice.

Remove the two or three screws holding down the barrel bridge. Lift out the barrel bridge which the barrel will be attached to. Re-attach the pin vice to the winding square of the barrel arbor; hold this in your left hand. Hold the barrel firmly with your index finger and thumb. At the same time, grip the pin vice in the palm of your hand. This is not easy for the first timer, but you will soon get used to it. Use your right-hand fingers to rotate the barrel slightly. This will rotate the Geneva stop work so that the finger piece is free of the cross piece's stop protrusion.

Hold it in this position by keeping a grip on both the barrel and the pin vice.

With your free hand, and using a screwdriver, unscrew the screw holding the cross piece in place and lift off the cross piece.

Slowly let the barrel rotate between your thumb and index finger until you have exhausted the small amount of power left in the spring, typically between a quarter to a full turn.

Before and during removal of this piece, check to see if there is a mark anywhere on the square that shows where the finger piece should be fitted. The finger piece should just lift off with a little persuasion, and you should now be able to safely remove the barrel cap and remove the spring for cleaning. Hand levers can be used at this stage, should you find yourself in difficulty.

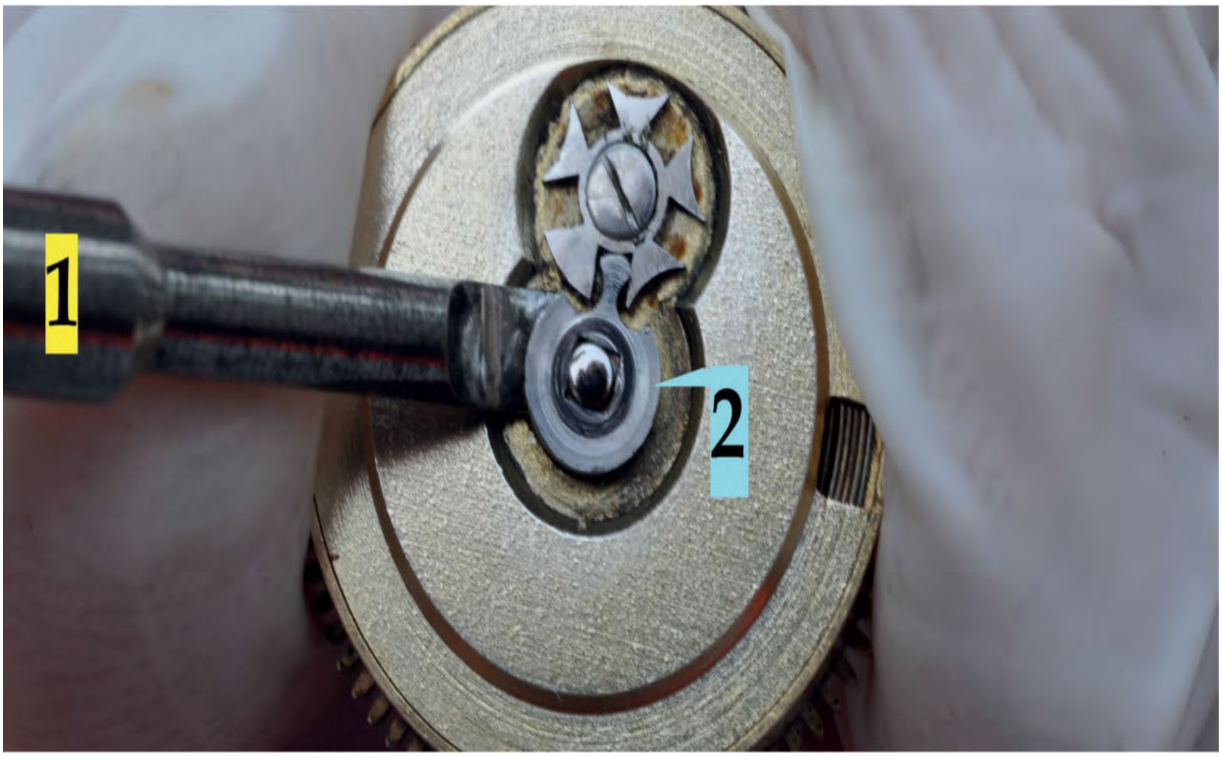


Fig. 278: Removing cross work from a barrel. (1) Hand lever. (2) Finger piece.

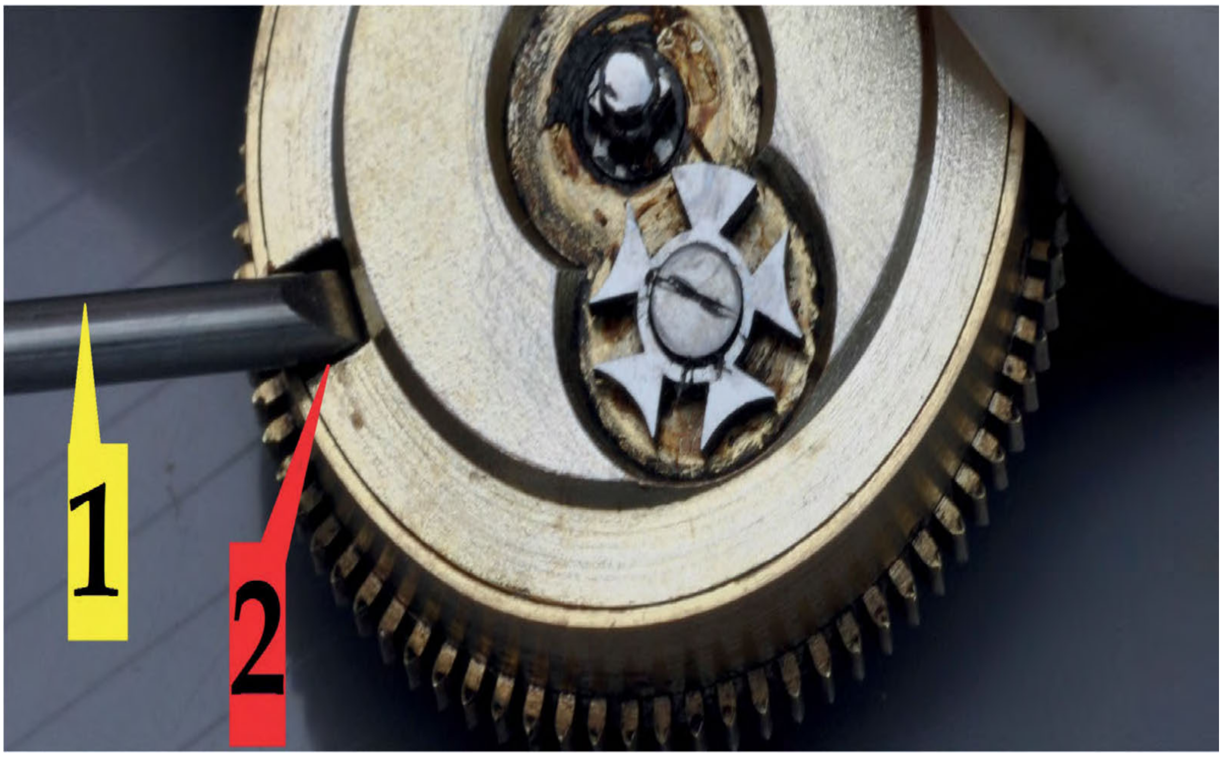


Fig. 279: Removing the barrel cap when a cut-out in the cap is present. (2) Using a screwdriver (1).

Setting up Geneva Stop Work

To set up Geneva stop work, refit the mainspring in the normal fashion, and fix the cross piece to the barrel cap and secure it with its screw.

Rotate the cross piece so the odd section (reversed radial surfaced end) is in line with the barrel arbor.

Attach the pin vice on the winding square as before, and hold the pin vice in your left hand, keeping your fingers and thumb free to rotate the barrel. Rotate the barrel clockwise until you feel that the spring has hooked on to the barrel arbor. Then let the barrel spin in your fingers slowly to let down the power.

Now we know that the spring is hooked.

The next job is to determine the number of turns the barrel arbor makes when winding up the spring.

Rotate the barrel and count the number of turns it makes. Once you have determined this number, we can calculate the set-up of the Geneva stop work.

If your watch has the normal five teeth on the cross piece, you will have to subtract four from the number of turns in the spring, then divide the surplus by three.

Fully wind up the spring in the barrel, and let down one third of the surplus you have just calculated.

Hold the barrel in this position and proceed to fit the finger piece, making sure to line up any marks you have previously identified. Adjust the cross piece so that the two lock when you try to wind the spring up further.

Let the spring down slowly, and the finger piece should lock on the cross piece. To check the function of the stop work, wind up the barrel between your fingers until it locks at full power. Release the power slowly. As this unwinds, you should see the stop work functioning. Make sure all is functioning correctly, then refit it into the watch.

43. FUSEE WATCHES

Tip: My advice is actually to keep clear of fusee watches until you have plenty of experience with basic modern watches, and you have great finger dexterity. Fusee watches are very easily broken and particularly fiddly to work with. If you do intend to work on them, for heaven's sake only work with scrap movements that have no case. They can be purchased for a small sum on the net and are great for practice.

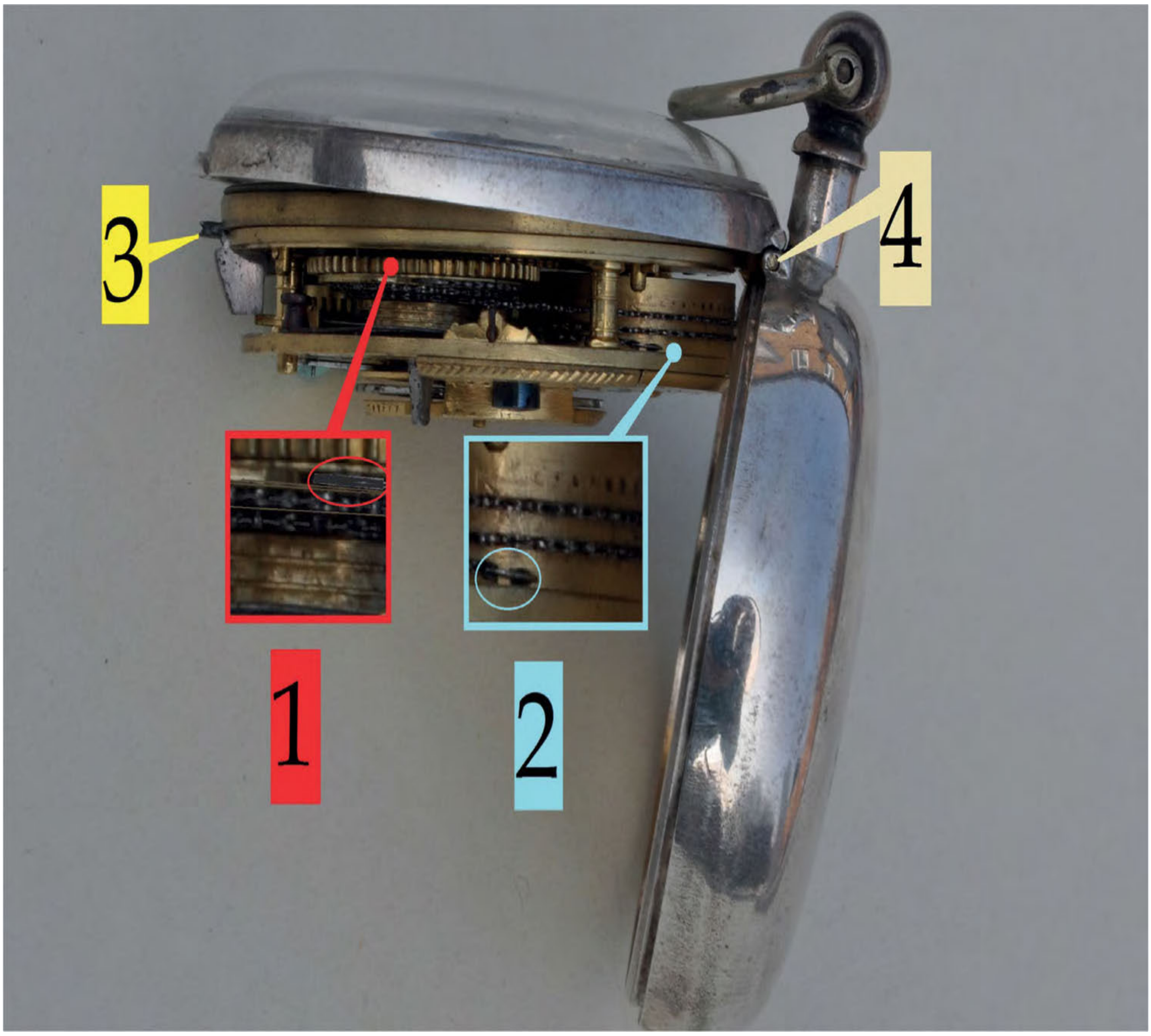


Fig. 280: A fusee watch. (1) The hooking point of the chain in the fusee. (2) The hooking point of the chain in the barrel. (3) Catch to release the movement, which allows it to swing open from the case. (4) Hinge pin that has to be removed before you can work on the watch.

A fusee is a cone-shaped device connected to the mainspring barrel by a chain. The chain is pulled round the barrel from the fusee as the watch runs. When fully wound the chain pulls from the small diameter of the cone. As the watch unwinds, the chain pulls from an ever-increasing radius to compensate for the reducing power of the spring; this is to ensure that the power provided remains constant throughout the unwinding of the watch.

PARTS OF THE FUSEE

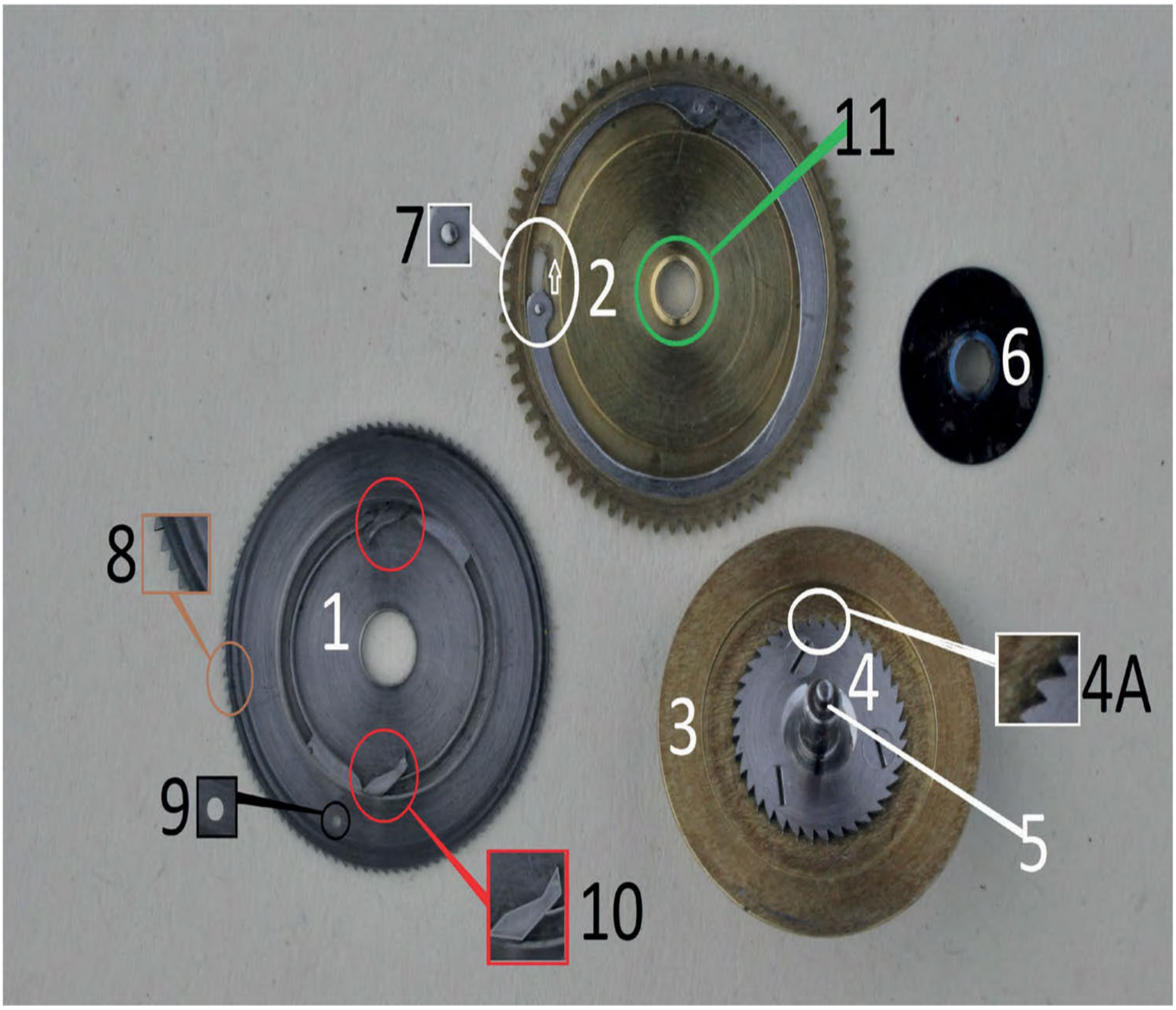
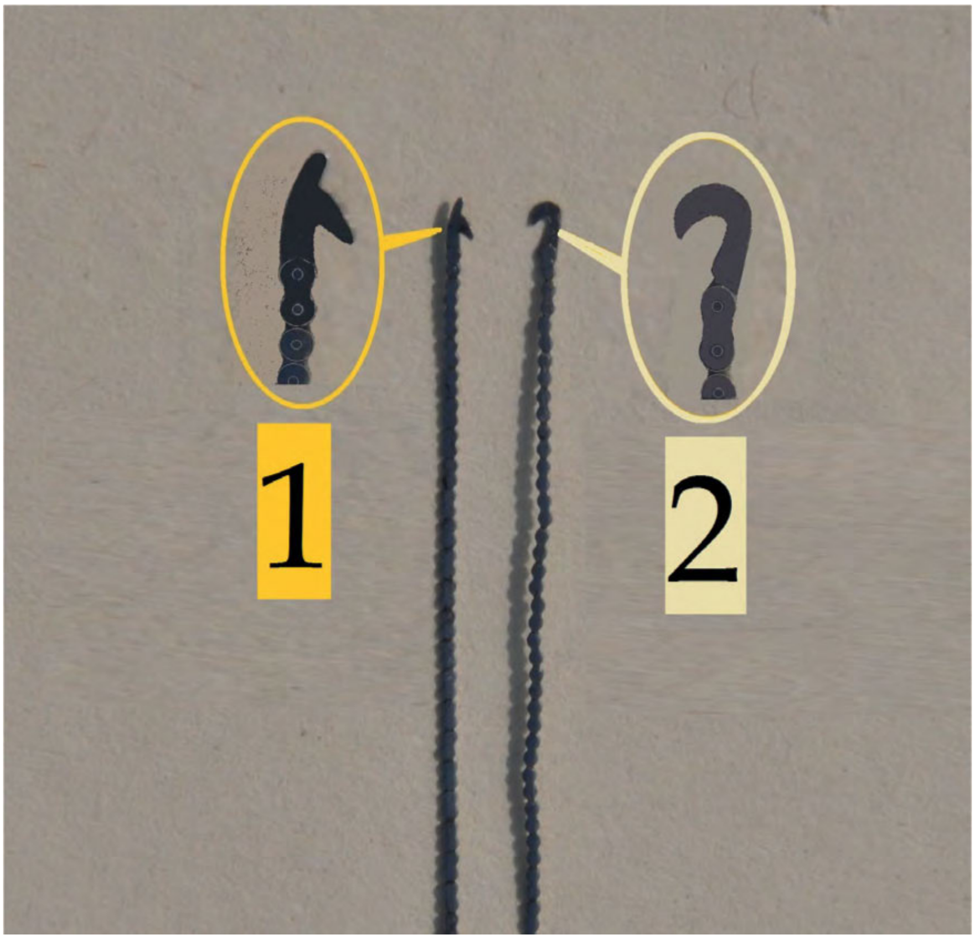


Fig. 281: Parts of the fusee. (1) Maintaining power ratchet wheel. (2) Great wheel. (3) Fusee. (4) Fusee ratchet. (4a) Close-up of the teeth of the ratchet. (5) Fusee arbor. (6) Washer through which the securing pin passes. (7) Maintaining power spring and its pin. (8) Close-up view of the maintaining power wheel's teeth. (9) Hole through which the maintaining power spring pin passes. (10) Ratchet click. (11) Great wheel bearing which rotates on the fusee arbor.

The Fusee

The fusee is a cone with a spiral groove cut into its surface running from top to bottom. The cone has an arbor fixed to its centre with a square at its top which is used for winding. The fusee and its arbor rotate in the plates of the watch. At the base of the cone is a gear called the great wheel. This gear would normally be fitted to the barrel in a conventional watch.

The fusee and great wheel are coupled together by a ratchet wheel and clicks, which enable the watch to be wound.



The Chain

Fig. 282: Fusee chain. (1) Hook that fits in the barrel. (2) Hook that fits in the fusee.

The chain is similar to a miniature bicycle chain with two outer links and one centre link, all held together with rivets, and all made out of hardened and tempered steel. A watch chain is normally 20cm (8in) long with a hook at each end. When the watch is wound, this chain winds round the fusee cone just like a spiralling snake, in the fusee’s groove.

One end of the chain hooks into the fusee cone at its largest diameter on to a pin that crosses the groove. This hook is shaped like a question mark. At the opposite end is a second hook, shaped like a lobster claw, which hooks into a hole in the barrel outer wall.

The Barrel

Unlike a conventional watch where winding is achieved via the barrel arbor, in a fusee watch this arbor remains stationary. It is kept stationary by a fixed click and ratchet wheel on the end of the barrel's arbor. The ratchet only rotates during the pre-tensioning of the spring for setup after servicing. The click is used for locking after setup.

HOW A FUSEE WATCH WORKS

Winding

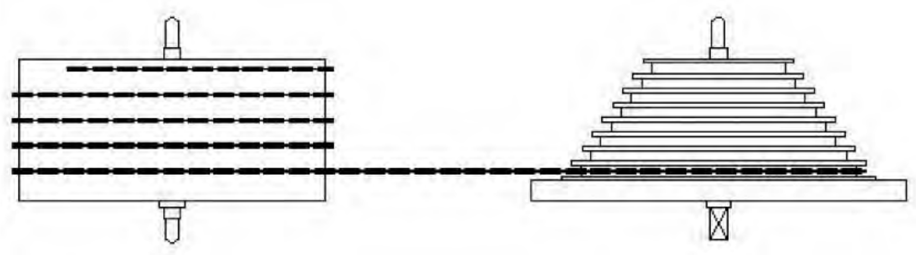
When a key is fitted to the square winding arbor and the watch is wound (anticlockwise), the fusee is turned but the great wheel remains stationary. The rotating fusee pulls on the chain.

The chain is slowly wound from the barrel wall and then wraps itself around the fusee cone. As this happens, the barrel rotates, coiling up the mainspring inside the barrel. To prevent all the chain being pulled off the barrel, there is a device called the stop iron. As the fusee nears full wind, the chain rubs against the stop iron. The stop iron lifts it up to engage with a protrusion on the top of the fusee cone, called the fusee snail, as seen in Fig. 285. This causes the stop iron and the fusee snail to lock to prevent further winding, and leaves at least half a turn on the barrel.

The last half turn on the barrel is needed to prevent all the spring's power at full wind bearing on the delicate hook. Instead, it spreads the load along the half turn of chain left on the barrel. This also means that a fusee uses the middle portion of the spring, just like stop work.

In a Nutshell

When the fusee is fully wound up, all the chain is on the fusee, and when it is wound down, the chain will be on the barrel wall. If you ever work on a fusee watch you must remember that there is always at least three-quarters of a turn of power on the mainspring. This is so when the watch is wound down, the chain has some power left on it to prevent the chain from sliding off the barrel and the chain unhooking.



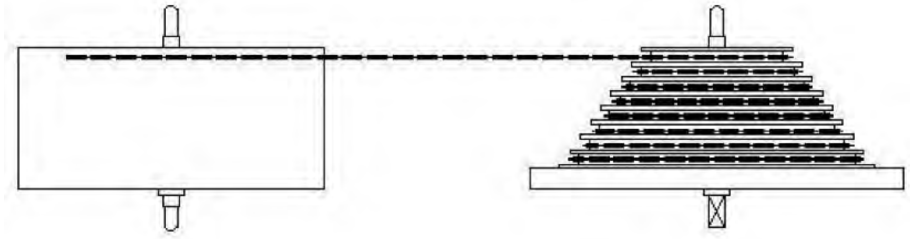


Diagram 28: Fusee unwound.

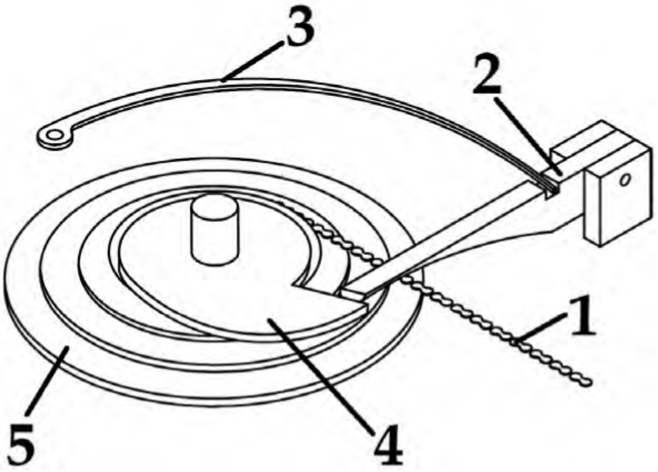


Diagram 29: Fusee wound.

Diagram 30: Fusee wound and stop iron engaged with snail-stop cam. (1) Fusee chain. (2) Stop iron. (3) Stop-iron spring. (4) Snail-stop cam. (5) Fusee.

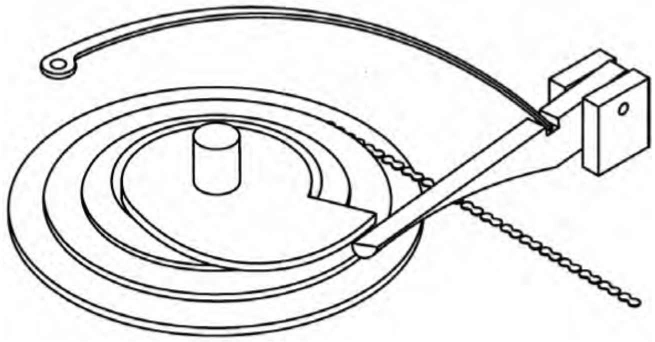


Diagram 31: Fusee unwound, and stop iron clear of the snail-stop cam.

Warning! Do not attempt to disassemble the watch at this stage, as there is a danger of injury from the mainspring. Ensure that *all* the power has been let off.

Letting Down the Power

The click and ratchet are sandwiched between the great wheel and the fusee cone, so letting down the power of the spring poses a problem. Following the instructions below will minimize the chance of any inadvertent damage to your watch.

Firstly, before attempting disassembly, apply some thick oil to both pivots of the centre wheel and that of the fusee pivots. This will help preserve the pivots and prevent them from seizing.

Fix the pin vice to the exposed centre wheel pivot (the shaft the cannon pinion was covering), making sure the pin-vice is nice and tight.

Next, remove the two screws that are holding down the train bridge on the front plate (dial side). It might be advisable to wear a thin pair of gloves for the next stages.

You will have to place the movement in the palm of your left hand and, with your index finger and thumb, you are going to have to have a firm grip on the pin vice as this will soon be holding the energy of the mainspring.

Using a set of tweezers in your right hand, lift off the train bridge and remove just the third wheel, and set it aside.

Slowly loosen your grip on the pin vice and let the gear train spin at a controlled and slow speed, until all the chain is wrapped round the barrel wall.

Next, let off the remaining set-up on the spring. This is simply a case of fixing the pin vice to the barrel arbor's square (in the middle of the barrel's ratchet). Loosen the screw of the exposed click on the front plate only one turn. Rotate the pin vice just enough to lift the click, so you can pull it clear of the ratchet wheel;then let the pin vice slip between your fingers.

The watch can now be taken to pieces safely.

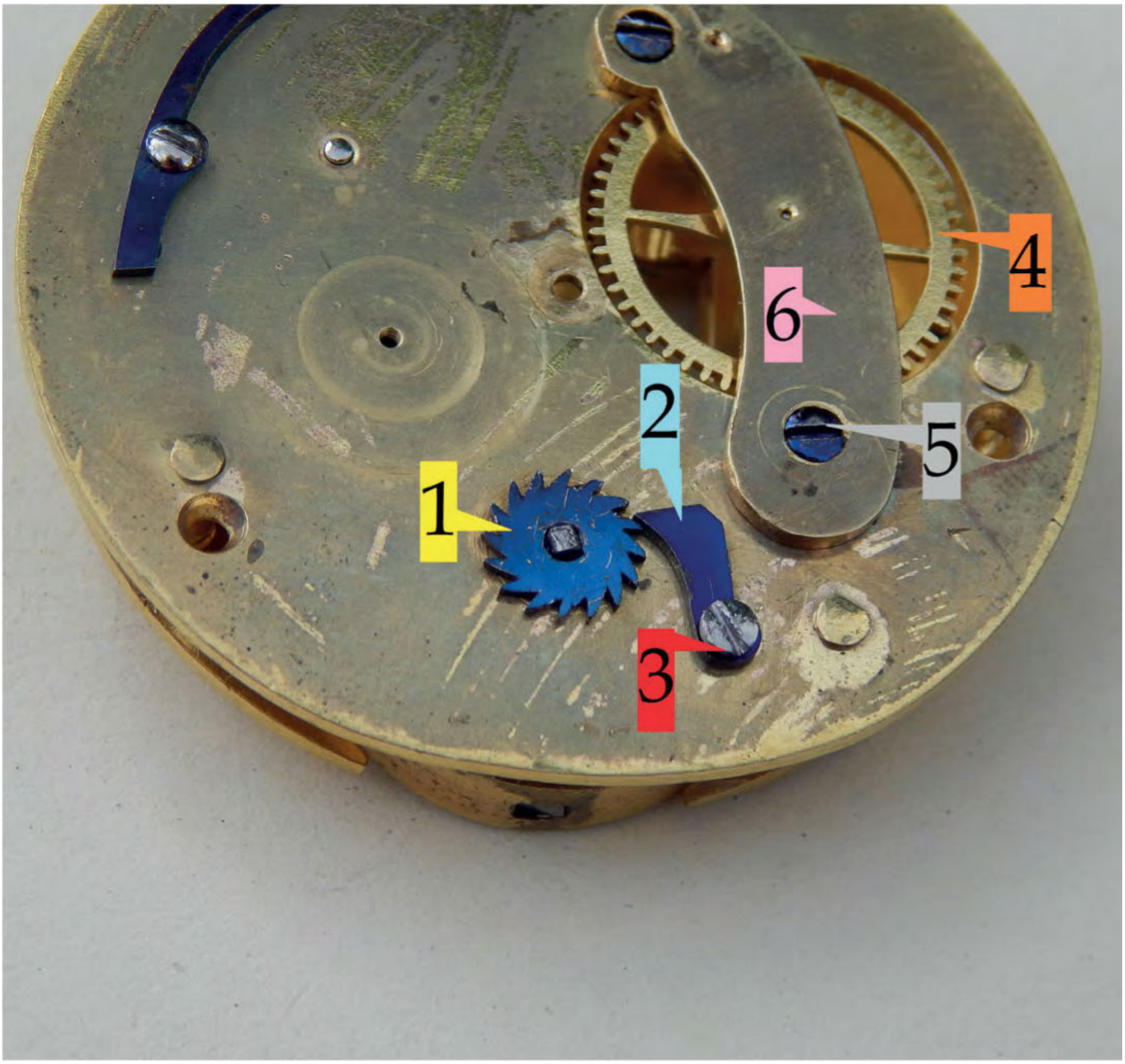


Fig. 283: Front plate view of a fusee. (1) Barrel ratchet. (2) Fixed click. (3) Locking screw. (4) Third wheel. (5) Third wheel bridge screw. (6) Third wheel bridge.

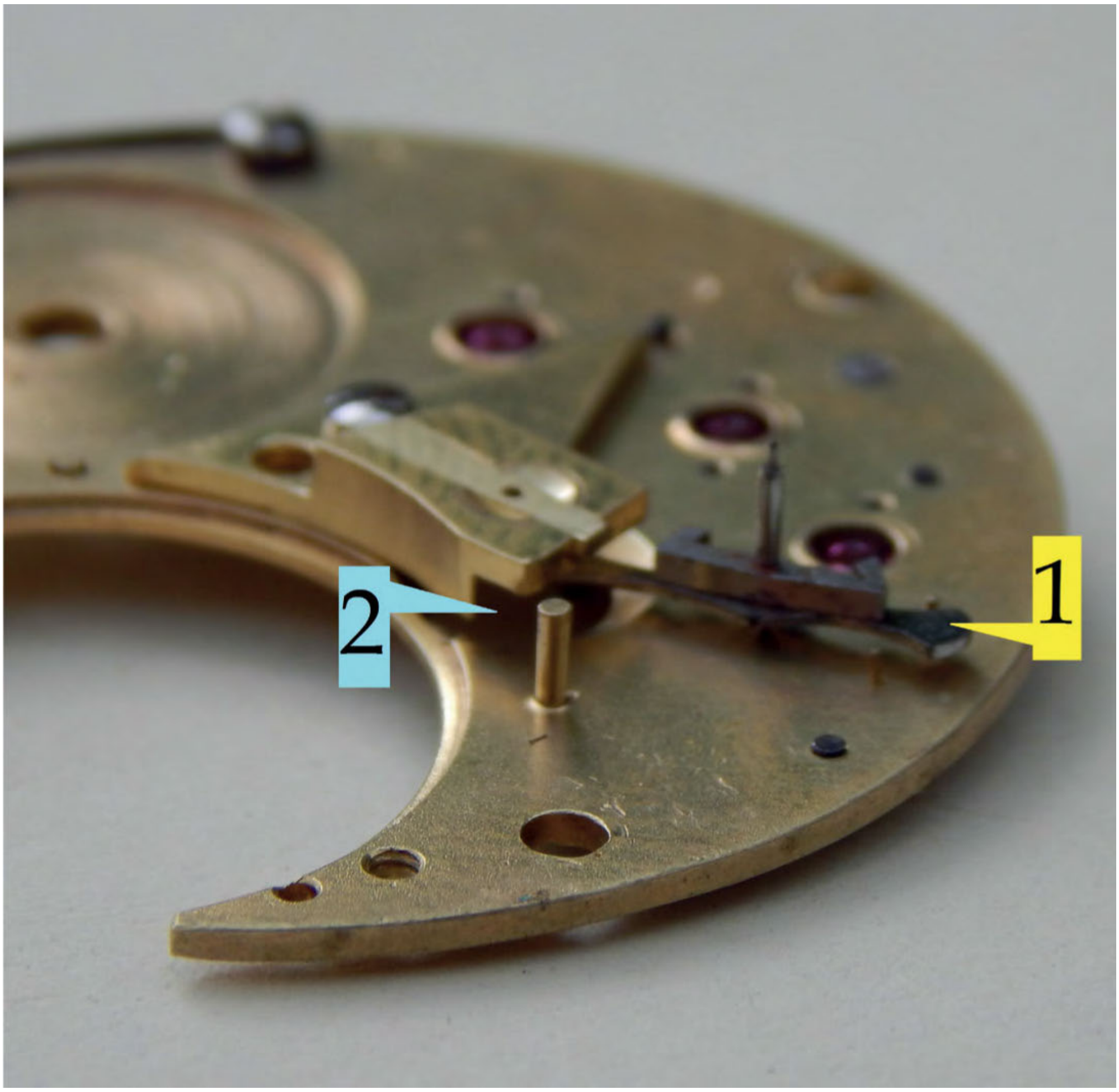


Fig. 284: (1) Pallet lever. (2) Balance support.

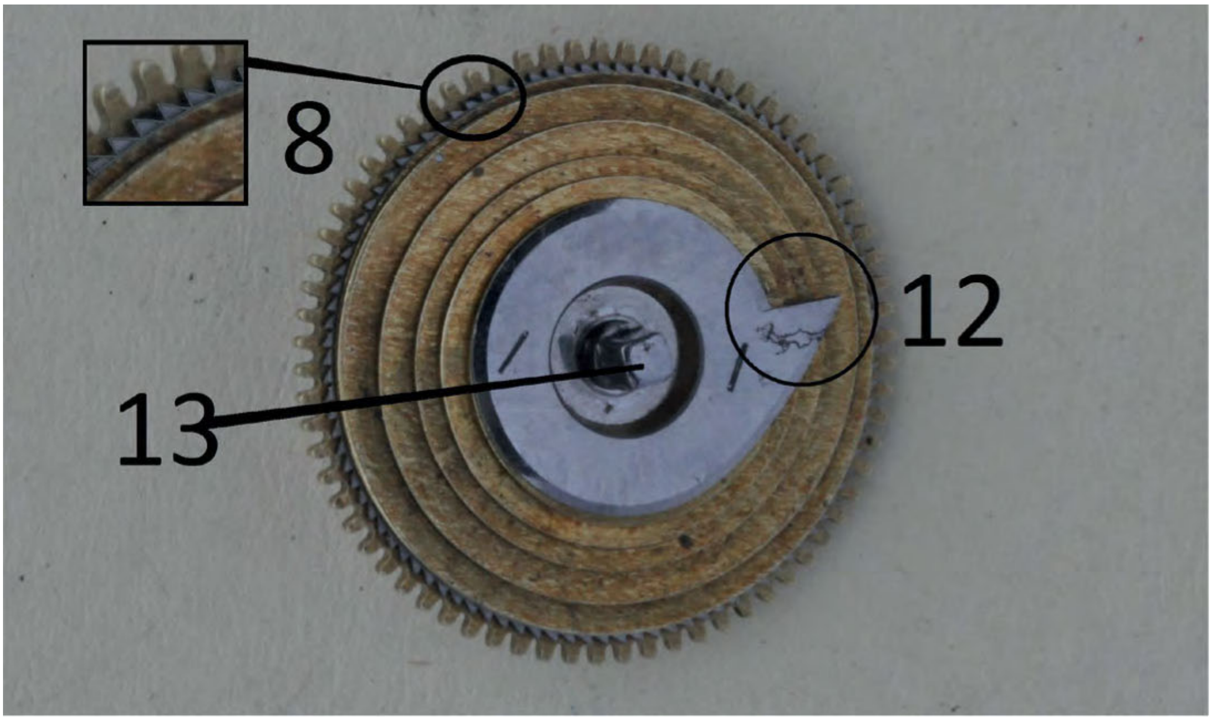


Fig. 285: Fusee. (8) Close-up of the teeth. (12) Fusee snail. (13) Winding square.

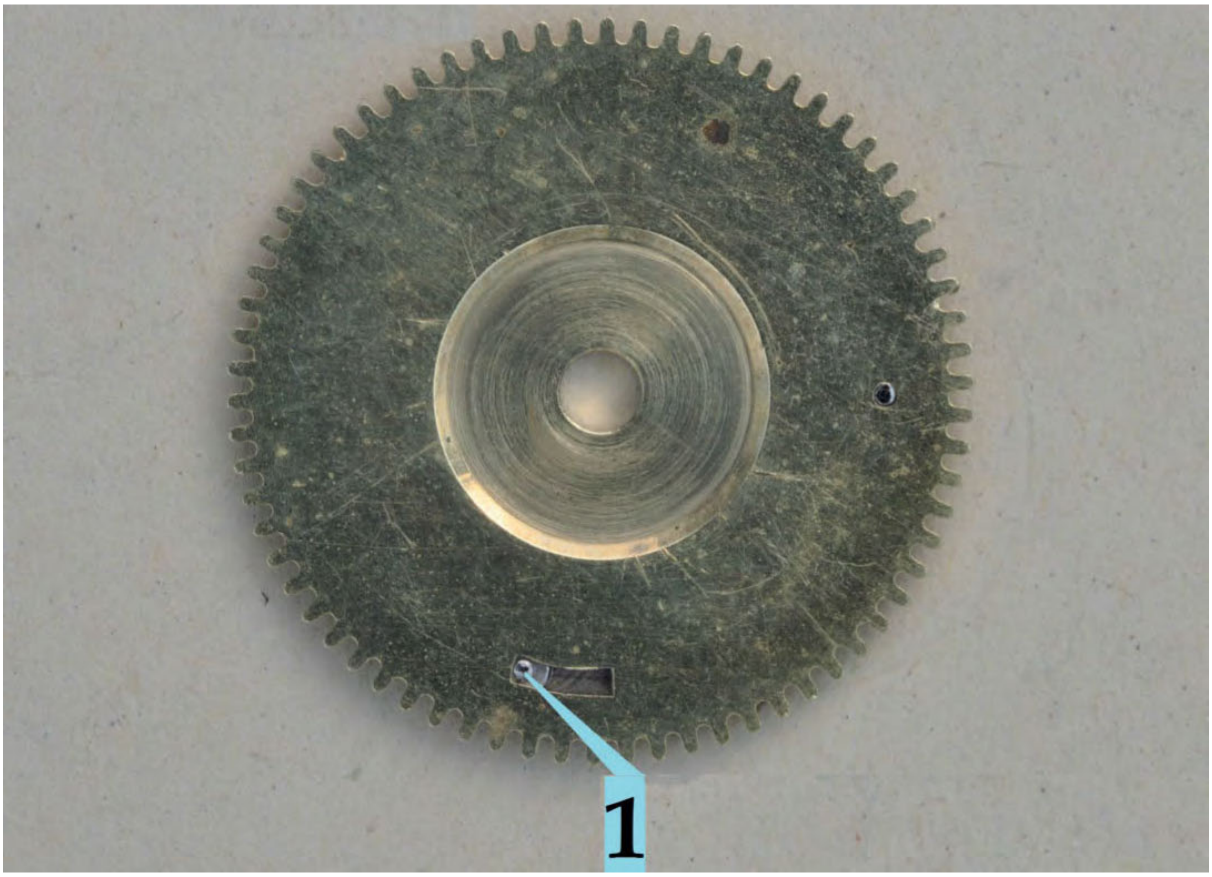


Fig. 286: Maintaining power spring pin poking through the great wheel.

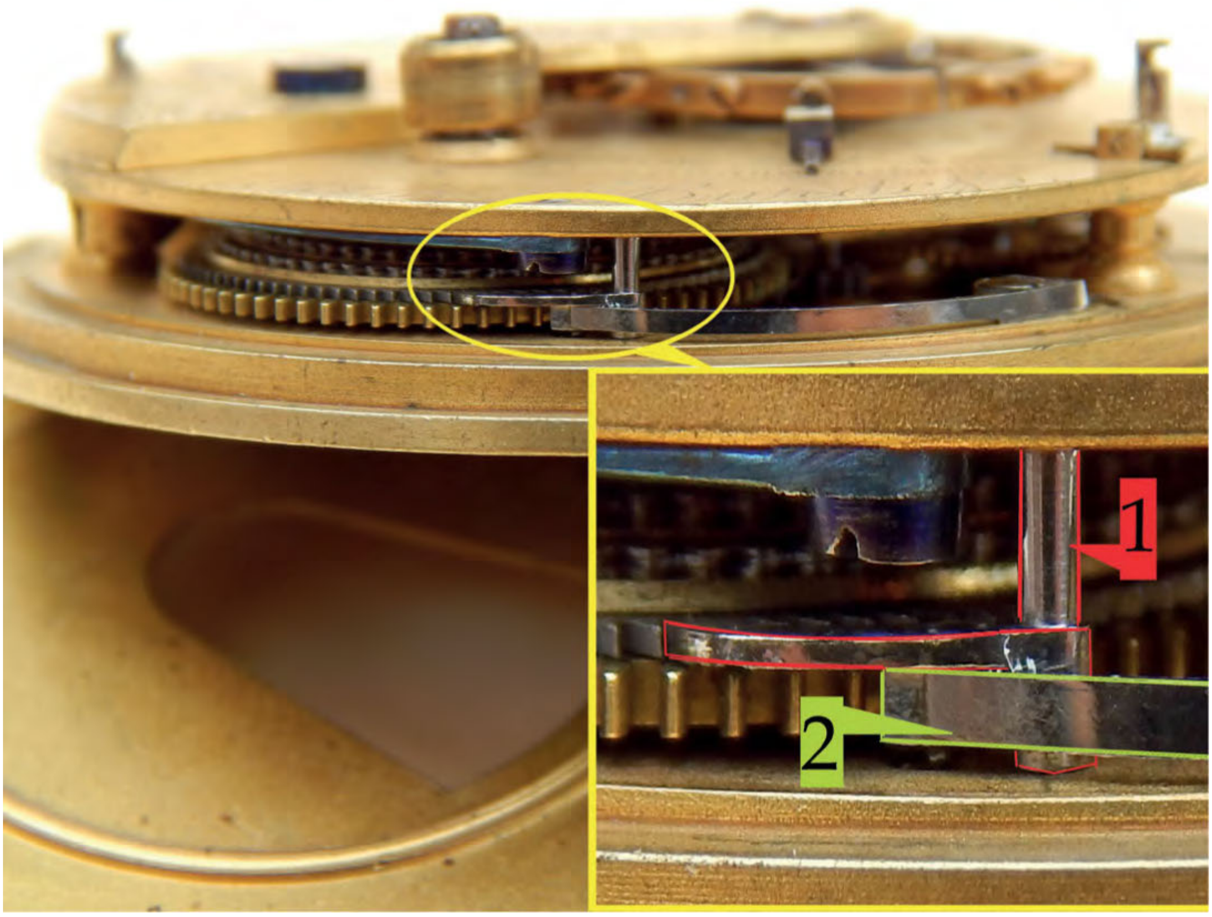


Fig. 287: (1) Maintaining the click. (2) Maintaining the click spring.

Please be careful as you remove the top plate as the pallet pivots are very easily broken. You may have to ease out the pallets first, when easing the plates apart. This is due to the fork end of the pallets passing through balance support. The pallet fork tends to get stuck in this, resulting in a broken top pivot.

THE MAINTAINING POWER

The maintaining power is a device needed to keep a fusee watch running during winding. You are not directly winding the spring – instead, you are turning the fusee during winding. This means that the power of the spring is cancelled out. This sudden loss of power can ultimately cause damage to the escapement as the watch tries to stop.

The maintaining power consists of a maintaining power ratchet wheel. This has fine ratchet teeth on which a click and spring engages (known as a detent with a spring); these are fixed to the main plate. During winding, the maintaining ratchet wheel remains stationary, but rotates with the great wheel during normal running of the watch. The maintaining detent slowly clicks over the teeth of the maintaining wheel.

The maintaining ratchet wheel is sandwiched between the fusee and the great wheel and is coupled to the great wheel by the maintaining power spring. One end is screwed to the great wheel and the other end of the spring pin protrudes though a hole in the maintain wheel (a loose fit). On the other side of the maintaining ratchet wheel is the pair of clicks for the fusee ratchet wheel, with matching springs to operate the clicks.

How It Works

The function of the maintaining power is to keep the watch running during winding.

To activate the maintaining power, the key is rotated in a clockwise direction. This is the opposite direction to the act of winding, and the key will only rotate about 4 degrees.

The great wheel will remain stationary, but this time the maintaining ratchet wheel will rotate, and its detent will click over about two or three of the maintaining ratchet wheel's ratchet teeth. This will prevent the maintaining wheel from springing backwards as the spring joining the great wheel and maintaining wheel has been giving it energy as it has now been bent.

For this energy to be spent, the great wheel will continue to rotate in the opposite direction of wind as if winding was never taking place. The energy in the maintaining power spring will drive the gear train for a few seconds until the mainspring takes charge again when the owner of the watch stops winding.

The best way to see it work is to wait until your watch is fully wound down. Turn the key clockwise the previously mentioned 4 degrees, and the watch should leap back to life, now being driven by the maintaining power. Once the watch is ticking away, this is now the correct time to wind it without fear of it stopping during winding.

RE-TENSIONING THE FUSEE AND REASSEMBLY

The movement is best assembled with the wheels, barrel and fusee fitted in the top plate, in the non-conventional upside-down manner.

Once the movement is assembled, the last job is fitting the chain.

Refit the chain’s question-mark shaped hook in the fusee first, and wind the majority of the chain on the cone using the watch’s key or a pin vice (this is done as if you were winding the watch).

Locate the end of the chain into the barrel’s wall. Rotate the barrel so the remaining chain wraps round the barrel’s wall. Try to maintain some tension on the chain to stop the hook from unhooking. You will have to keep your thumb on the barrel at all times to maintain this tension on the barrel, as the chain may slide off. Alternatively, a big blob of Rodico can be used to hold things still.

Next, remove the small train bridge. Take out the third wheel. Fit a pin vice on the barrel arbor’s square on which the ratchet wheel resides.

Rotate the pin vice anticlockwise. This will put energy into the spring and it will rotate the gear train. Again, you must maintain some tension with your thumb on the barrel so that if the chain goes slack, it will not be able to slide off the barrel’s wall (wear a finger cot. Rodico will be no good for this, sorry). Once all the chain is on the barrel, hold it in place with your blob of Rodico and fit the ratchet on the barrel arbor’s square.

Pretension the spring with three-quarters of a turn. Lock the click into the ratchet wheel and tighten up the screw.

Put on a pair of safety goggles for this next step, as the chains are normally quite old, and may flick off.

Refit the third wheel, replace the small train bridge, and wind up the watch, keeping an eye on the fusee chain as you do so to make sure that for the first wind it runs in the grooves of the fusee cone (remember to remove the Rodico first). If the chain moves off the groove, it can be put back into place using a pair of tweezers.

Note: To accurately set up the pretension on a fusee, a fusee-adjusting rod should be used. These are only available on the antique market now, making them quite pricey.

44. OTHER ESCAPEMENTS

THE ENGLISH LEVER

The English lever escapement preceded the Swiss lever and was widely embraced by English watchmakers, at least up until the turn of the twentieth century. It faded into obscurity as the Swiss lever proved slightly more robust and was more suitable for mass production – not to mention the fact that English watchmaking was well into decline by this time, with only the likes of Smith and Timex bashing out affordable timepieces.

The only visible difference between the English lever and the Swiss is that the escape wheel is a different shape. Instead of having the classic Swiss club-shaped teeth, the English lever has wedge-shaped teeth with a very slightly flattened tip for strength. In place of an inline escapement (where the escape wheel pallet lever and the balance wheel are all in a straight line), the escape wheel and balance wheel are normally at right angles to each other.

The action of the escapement is basically the same, with one small difference. As the escape wheel teeth only have a miniscule impulse plane as they are so pointy, the impulse planes of the exit and entry pallets are generally longer, so as to give a similar amount of energy transfer from the pallet lever to the balance wheel.

This type of escapement is also more commonly found with a single roller, rather than the typical double roller found on the Swiss lever.

PIN PALLET ESCAPEMENT

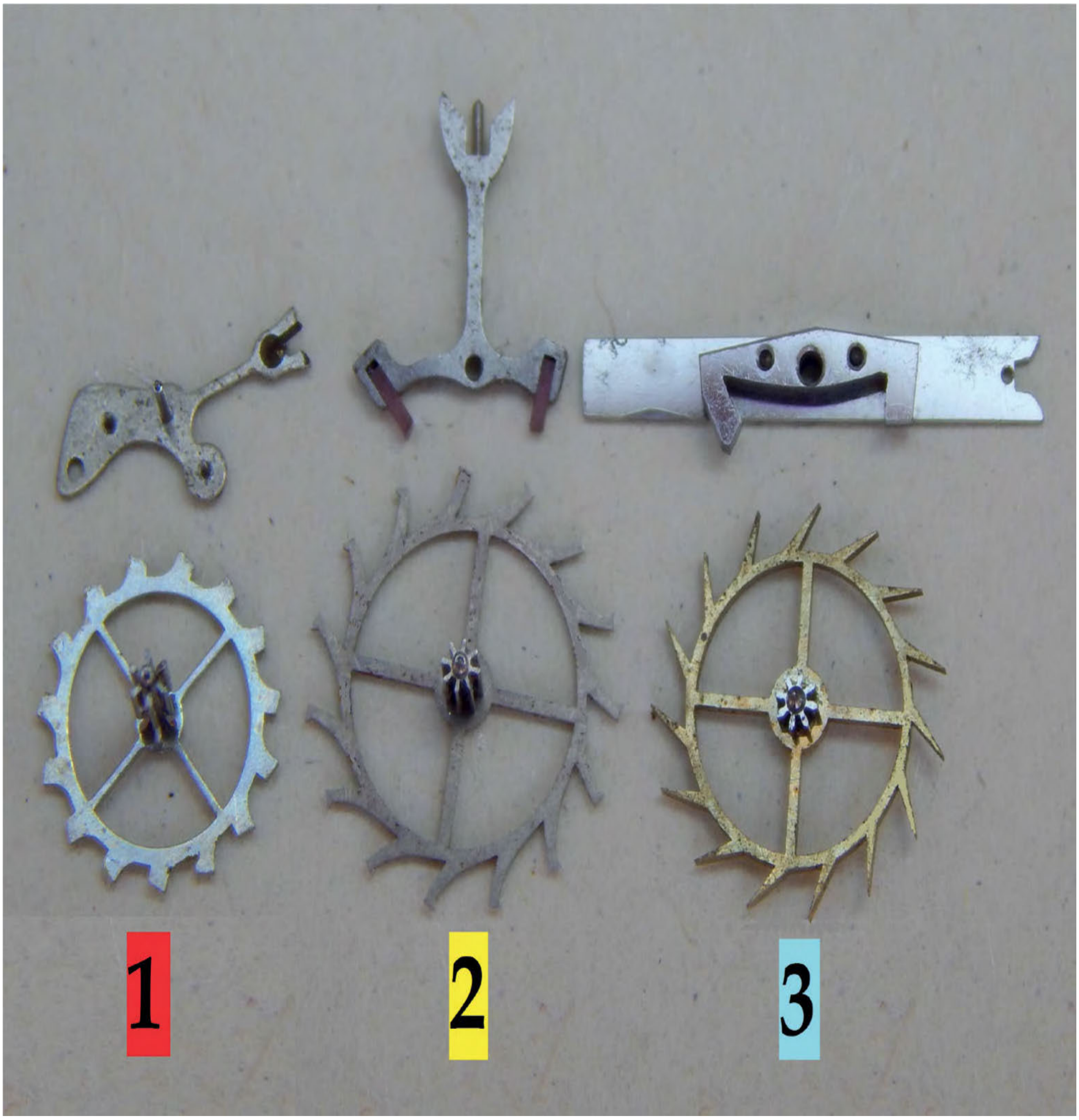


Fig. 288: (1) Pin pallet escapement. (2) Swiss lever escapement. (3) English lever escapement.

The parts of this escapement are very similar to those of the Swiss lever escapement, but simplified. They are made as cheaply as possible, using pressed brass and replacing any jewelled components with steel pins. Instead of pallet stones, pallet pins are used. The root of the escape wheel tooth is utilized for run to banking.

CYLINDER ESCAPEMENT

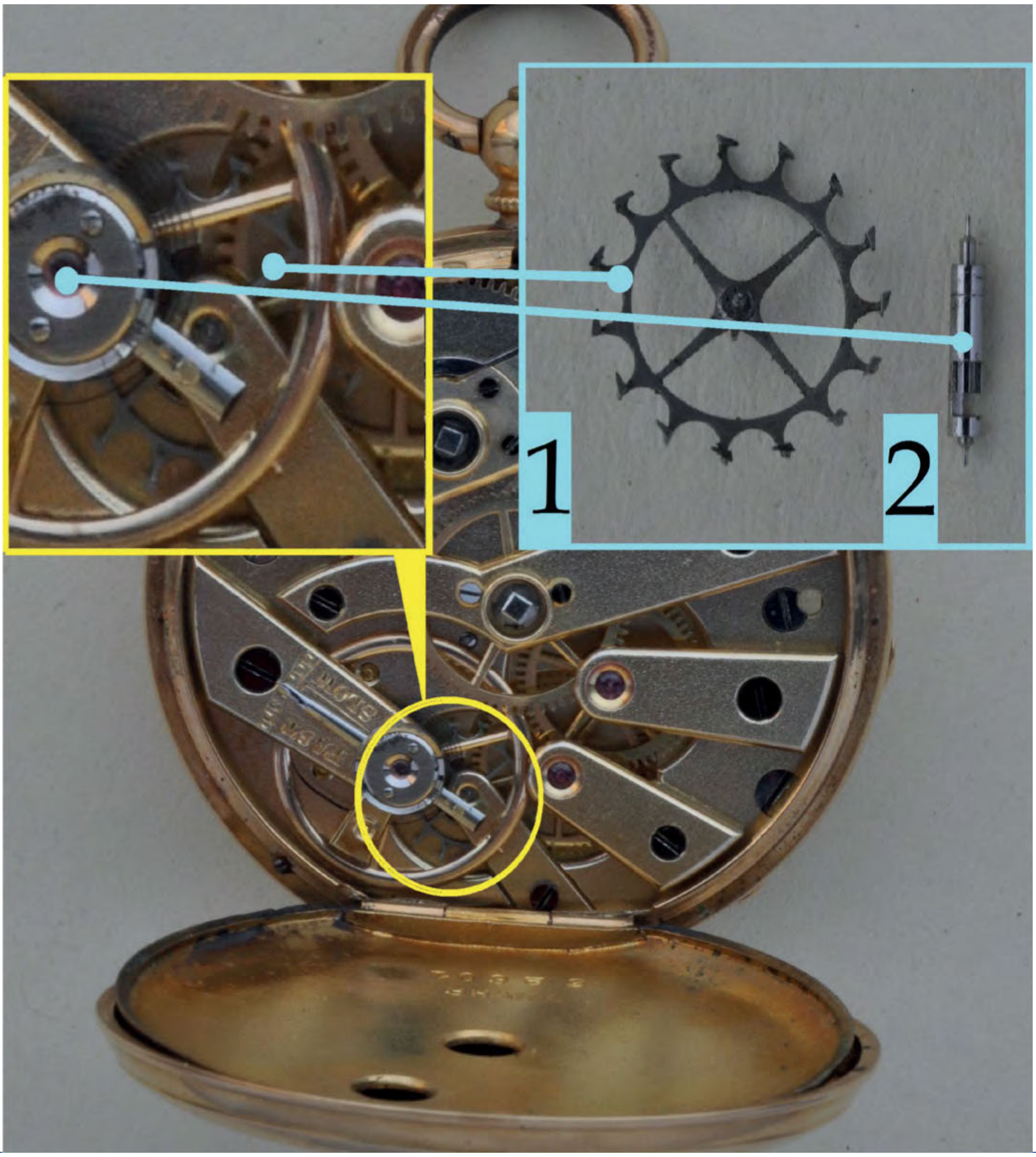


Fig. 289: Cylinder escapement. (1) Position of the escape wheel. (2) Position of the cylinder.

The cylinder escapement was an improvement in timekeeping over the verge escapement, but wasn't without its disadvantages. They are very delicate and hard to make by hand.

The Escape Wheel

This escape wheel varies from the Swiss lever, in that the ends of fifteen teeth project upwards to form stalks or posts. Mounted on top of these are wedge-shaped blocks which point to their neighbour. Looking more closely at these wedge teeth, the very outer edge forms the impulse face and the fat end of the tooth is known as the heel. This is undercut so as to clear the cylinder when the tooth is inside it.

The Staff

The main body of the staff is a hollow cylinder made from hardened and tempered steel with a highly polished surface. Pressed into the ends of this cylinder are two tapered plugs with a pivot formed on each end. These plugs are also made of hardened and tempered steel. The cylinder itself is a friction fit into the centre of the balance wheel. The balance rests just over half way up the cylinder.

Looking at the bottom half of the cylinder, under the balance wheel is a hole shaped like a Z-shaped Tetris block. This opening in the cylinder is called the ‘great opening’. The vertical faces of the great opening are known as the lips. The longer lip is called the entry lip, and the smaller top lip is known as the exit lip. They are essentially the pallet stones of the escapement, and receive the impulse from the impulse faces of the escape wheel as it enters and exits the cylinder, to keep the balance wheel in motion.

Just below the smaller exit lip is a smaller cut-out, called the ‘small opening’. This is to provide clearance for the escape wheel tooth inside the cylinder, when the balance turns clockwise allowing the top and bottom of the cylinder to completely clear the escape wheel.

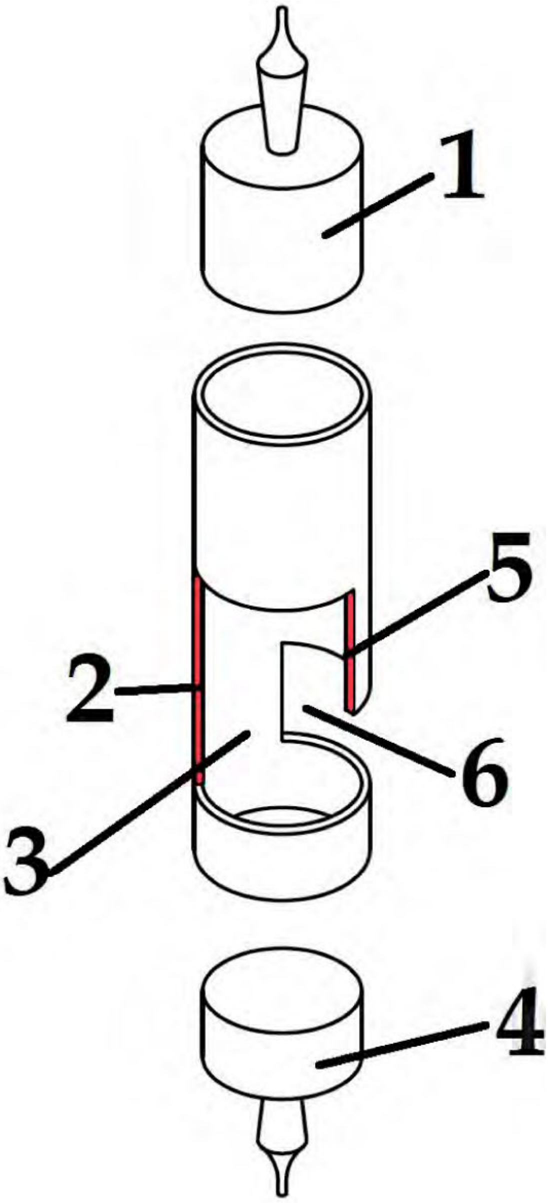


Diagram 32: Deconstructed cylinder: (1) Top plug. (2) Entry lip. (3) Opening. (4) Bottom plug. (5) Exit lip. (6) Small opening.

Action of the Cylinder Escapement

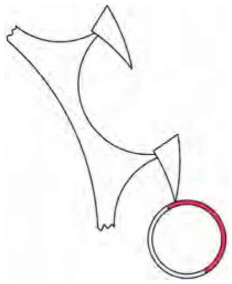
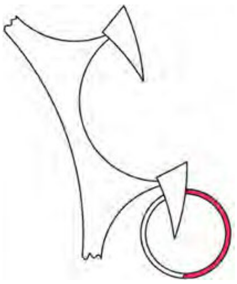


Diagram 33: Cylinder escapement. Escape wheel tooth locked on the outside of the cylinder.



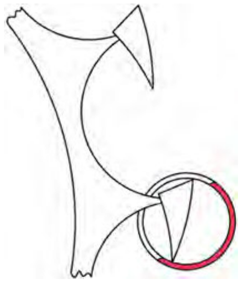
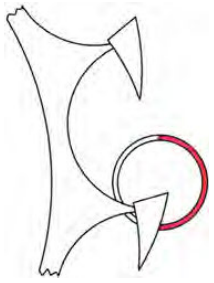


Diagram 34: Cylinder escapement. Escape wheel entering the cylinder and giving impulse to the entry lip.

Diagram 35: Cylinder escapement. Escape wheel tooth locked inside the cylinder.



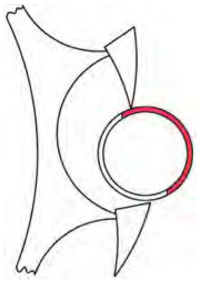


Diagram 36: Cylinder escapement. Escape wheel tooth exits the cylinder and gives impulse to the exit lip.

Diagram 37: Cylinder escapement. Escape wheel tooth locked on the outside of the cylinder. The sequence repeats.

The balance wheel swings anticlockwise, reaches the climax of its swing and reverses direction. During this time, a tooth of the escape wheel is locked on the outside wall of the cylinder. It remains stationary and its pointed tip just glides on the outside of the cylinder as the balance swings.

As the balance wheel rotates, a tooth enters the great opening of the cylinder. Remember that the side of the tooth is a wedge shape. As it moves into the cylinder it presses on the entrance lip, forcing the cylinder to rotate. This gives it an impulse to keep the balance oscillating. The tooth parts company from the entrance lip and drops on to the inside of the cylinder until it strikes the inside of the wall of the cylinder, thus locking the escapement with a tooth now on the inside of the cylinder.

The balance wheel continues to swing clockwise. The tooth is now entirely within the cylinder. The small opening passes over the escape wheel. The locked tooth drags on the interior wall as the balance continues its swing, until the balance reaches its climax and rotates in the opposite direction. The exit lip approaches, and the tip of the escape wheel’s locked tooth is now free: as it escapes the cylinder it pushes its way out. This provides the second impulse.

As the tooth leaves the cylinder (drops out), it has now finished its second impulse and a tooth on the opposite side of the cylinder strikes the outside of the cylinder’s wall and locks the gear train. The cycle repeats.

VERGE ESCAPEMENT

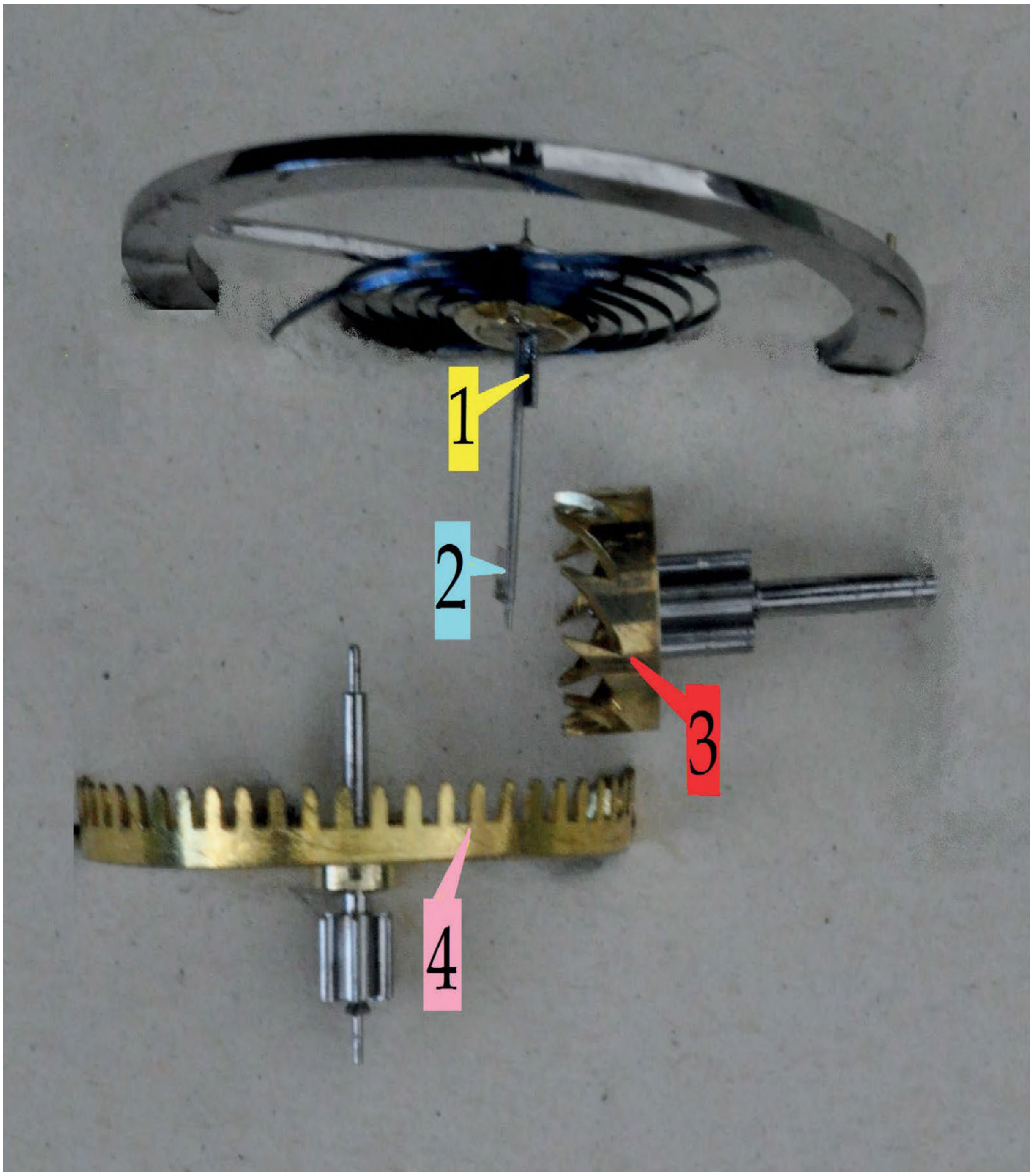
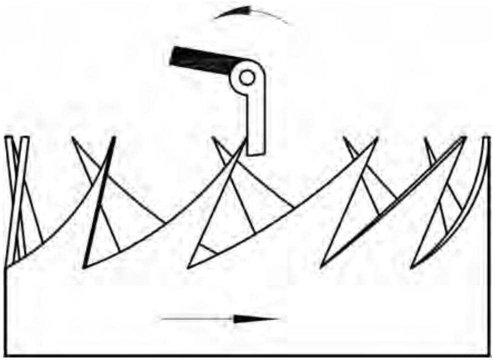


Fig. 290: Verge escapement. (1) Top pallet pad. (2) Bottom pallet pad. (3) Escape wheel. (4) Contrate wheel.

This escapement is one of the oldest of all the escapements that we have looked at.

It is quite simple, consisting of an escape wheel that resembles a pointed crown with saw-shaped teeth. It always has an odd number of teeth, and this is vital for the escapement to work. The balance staff (known as the verge) crosses the centre line of the escape wheel, making this a vertical escapement. The verge has two pallet pads, shaped like paddles, which are an integral part of the staff. These pallet pads are positioned on opposite sides of the escape wheel, and they are offset on the staff at approximately 90–110 degrees from each other.



Action of the Escapement

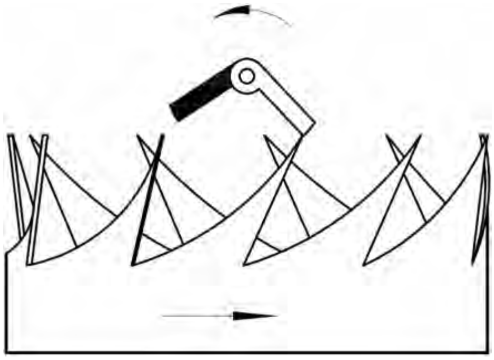
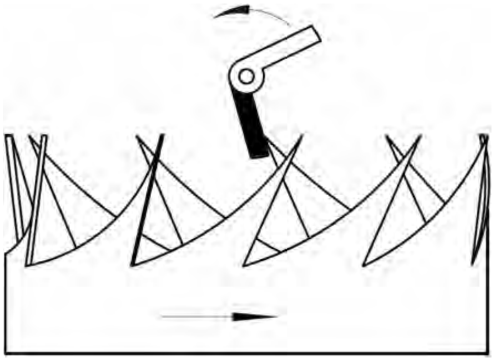


Diagram 38: Verge escapement. With the pallet-receiving impulse.

Diagram 39: Verge escapement. End of the impulse on the white pallet.



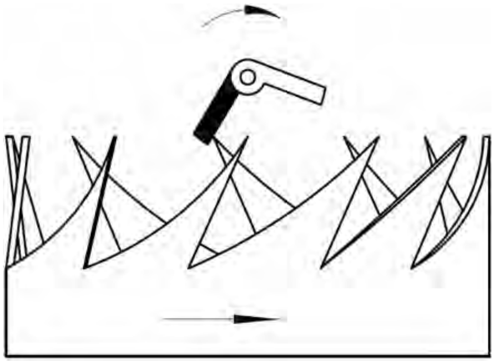


Diagram 40: Verge escapement. Escape wheel drops off the white pallet and locks on to the black pallet.

Diagram 41: Verge escapement. Impulse is given to the black pallet.

The balance rotates clockwise, and the escape wheel is held in the locked position by the top pallet pad as the balance staff and pallets are one. This also causes the escape wheel to recoil slightly.

The balance spring overcomes the inertia of the balance wheel and reverses the direction of motion, making the balance rotate in an anticlockwise direction.

The escape wheel is also now slowly moving and pushing on the top pallet pad, giving the balance wheel an impulse, until the escape wheel tooth eventually drops off the top pallet pad. The escape wheel is now in drop until a tooth locks on to the opposite pallet pad.

The balance wheel continues to rotate anticlockwise, causing the escape wheel to recoil slightly until the balance runs out of energy and the balance spring overcomes the inertia again.

This causes the balance to reverse direction, so it is turning clockwise again. The escape wheel is now pushing on the bottom pallet pad, giving it impulse, until this tooth discharges from the pallet pad and is in drop. When a tooth locks on to the top pallet pad, the balance wheel continues to rotate, causing the escape wheel to recoil. The action repeats.

45. SWEEP SECONDS

Like all things, the wristwatch has evolved over time and a sweep seconds hand is a relatively modern choice of a watch dial's layout. The seconds hand has been around for some time, but never really caught on until the mid-twentieth century. The most common layout for any watch was to have a small seconds hand that was offset (positioned) at six o'clock on the dial (face). We call this dial layout a subsidiary seconds dial. By having a watch with a centre seconds hand makes things a bit more complicated, as the gear train has to be jumbled around to accommodate the seconds hand in the centre position of the watch. It also means keeping the gear ratios the same, and keeping the hands turning at the correct speed.

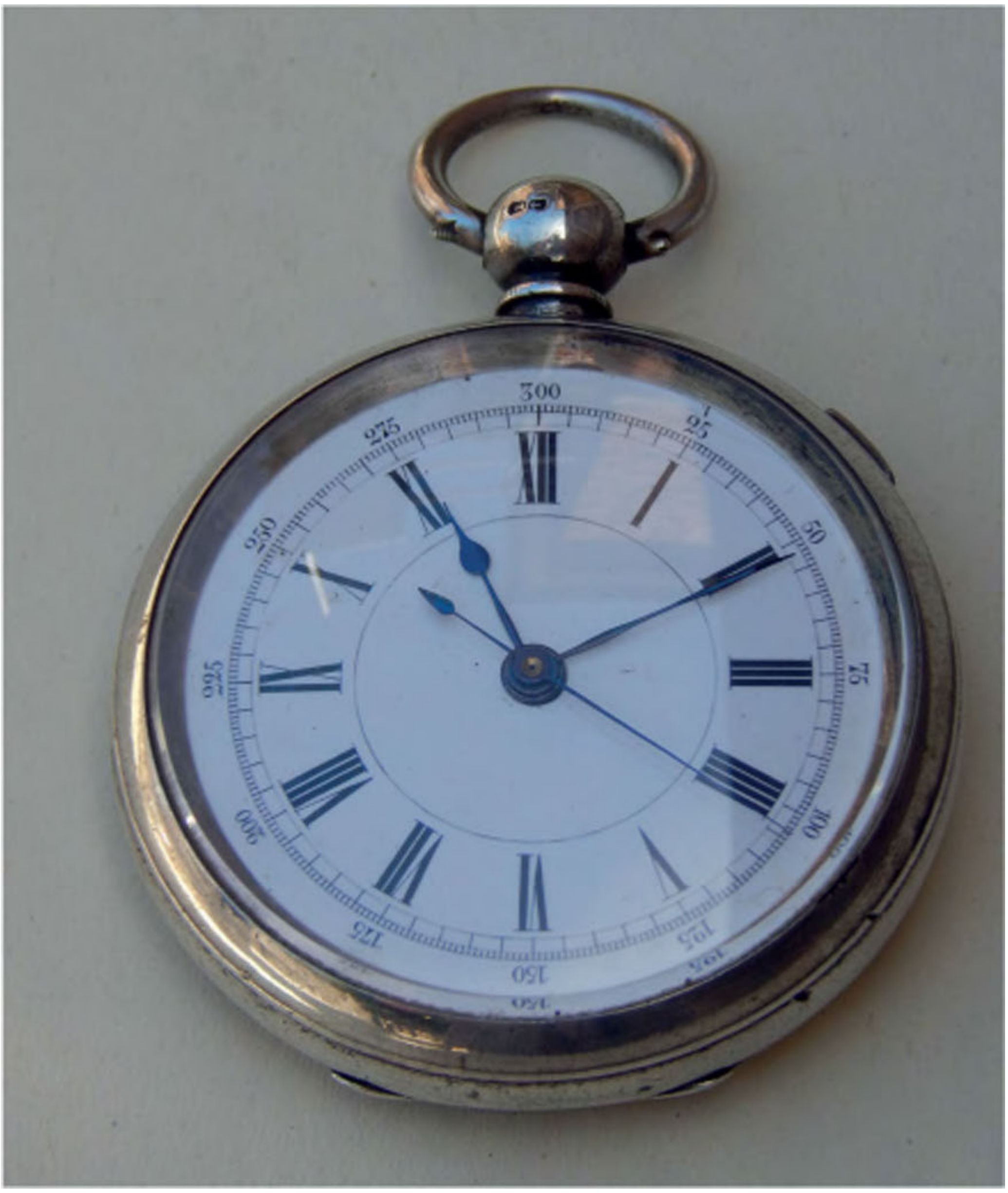


Fig. 291: Pocket watch with centre seconds hand.

Seconds hands are commonly driven by the fourth wheel, as it normally rotates once every sixty seconds. To achieve this, manufacturers add an extended pivot to create a subsidiary or centre seconds hand. There are two ways of achieving a centre seconds hand in a watch, by having direct drive or non-direct drive gearing. The most satisfactory method of driving a seconds hand is to have a direct drive. This is where one gear is driven and drives another.

NON-DIRECT DRIVE

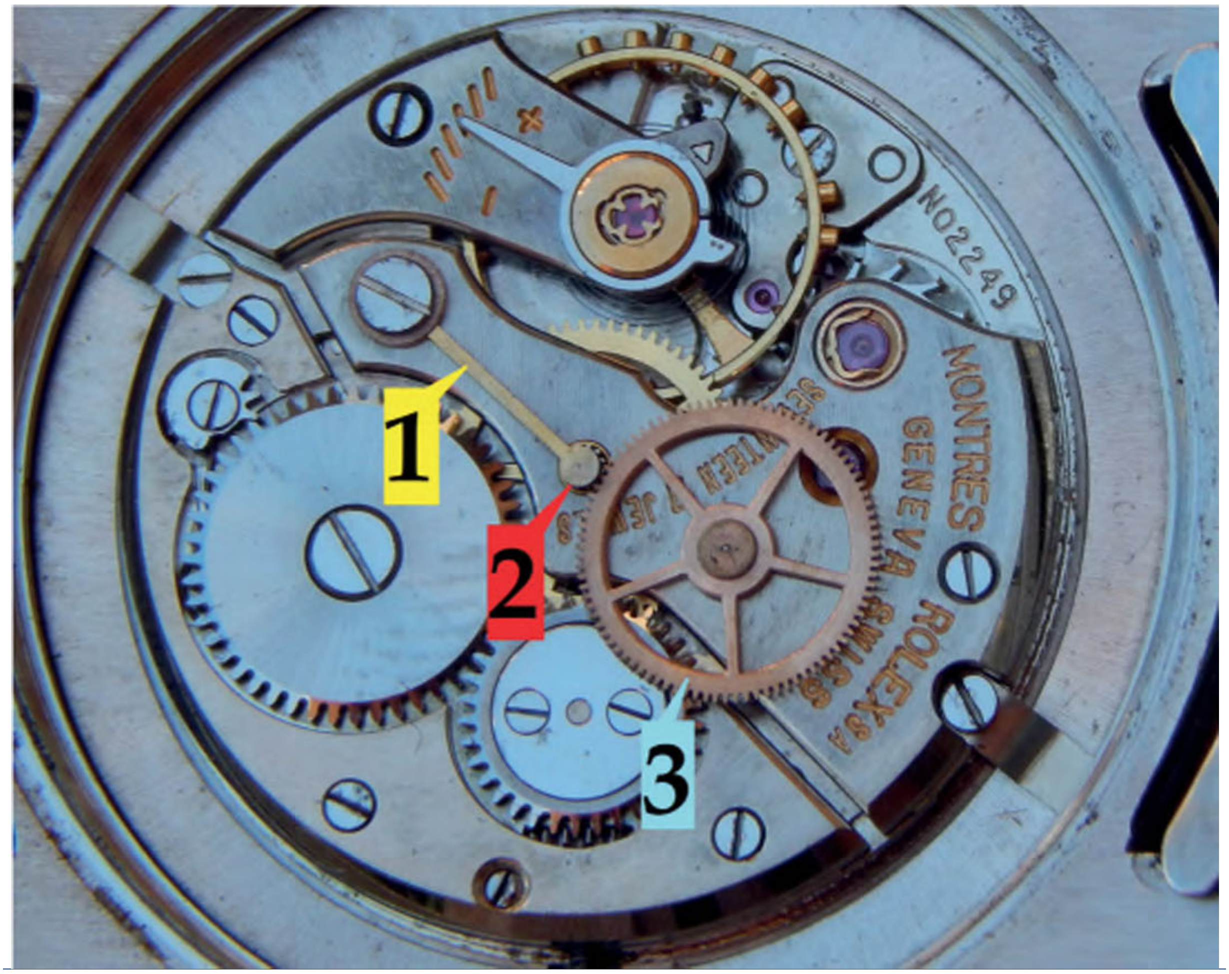


Fig. 292: Rolex with a non-direct-drive centre seconds hand. (1) Leaf spring (for dampening the gear backlash). (2) Centre seconds pinion. (3) Drive wheel for the seconds pinion fitted on top of the third wheel's pivot.

A non-direct drive is where you have the third wheel driving two pinions: the fourth wheel pinion and a second sort of dummy fourth wheel pinion, still rotating once every sixty seconds. As this dummy pinion/centre seconds pinion drives nothing, it has the disadvantage of causing a natural trembling effect: as it rotates, it has nothing to transfer its energy to. If a seconds hand were fixed to it in this state, the weight of the hand would cause it to bounce back and forth about five seconds. This is caused by the backlash (slop) between teeth. This backlash is needed for a smooth transition, and the only way to stop this bouncing affect is to add a dampening spring to the end of the centre seconds pinion to simulate a direct drive. This does, however, mean that you are adding friction into the system. If the watch is knocked hard enough, the pinion may still lunge one way or the other.

In the beginning of the twentieth century, watch manufacturers found that the simplest way of creating a sweep seconds hand was to take an existing production movement and use the non-direct drive technique. They commonly extended the third wheel's top pivot and retrofitted a drive wheel called the 'upper third wheel'.This would drive a pinion called the 'seconds pinion'.The seconds pinion passes through a hollowedout centre wheel's arbor and cannon pinion with an opened end. Resting on the top of the seconds pinion is the leaf spring for dampening the backlash.

The pictures show the seconds pinion and backlash between the second pinion and the driving upper third wheel.

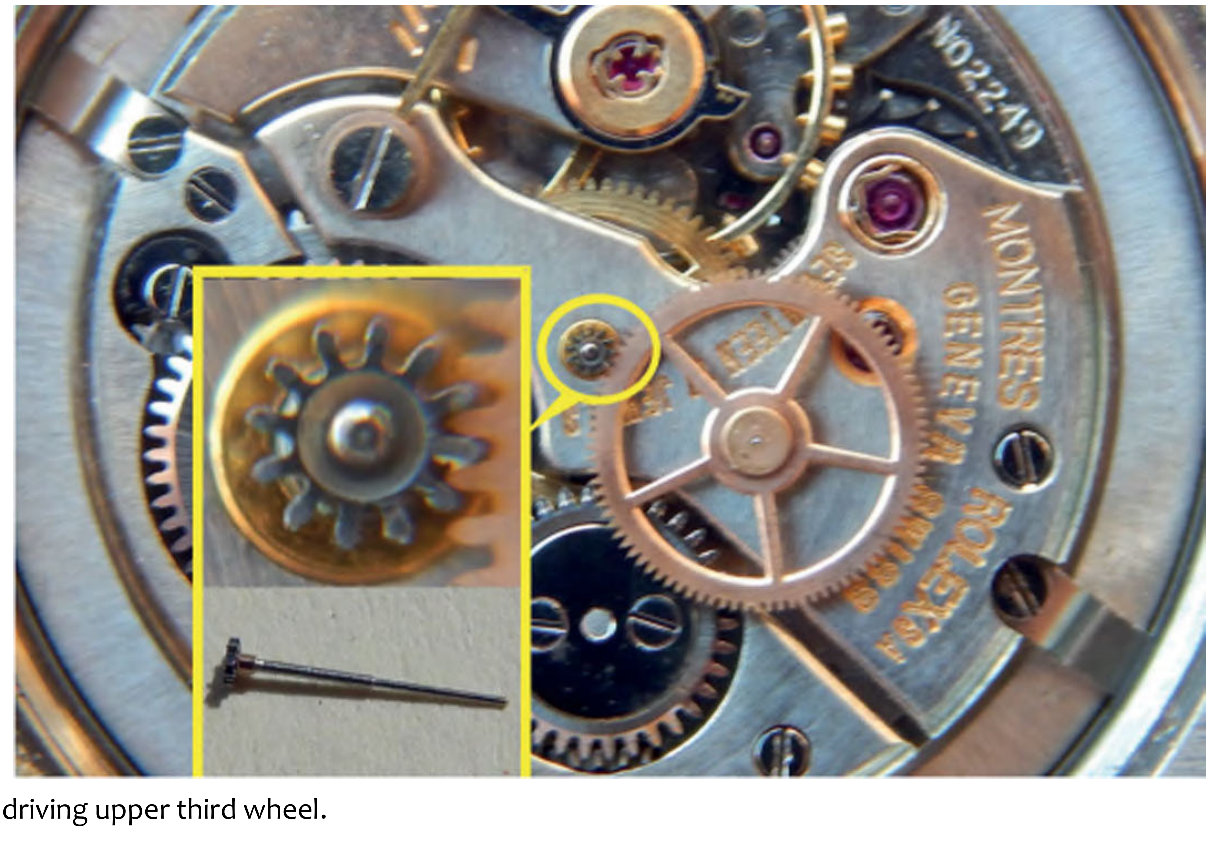


Fig. 293: The centre seconds pinion with the leaf spring moved out of the way.

DIRECT DRIVE SWEEP SECONDS

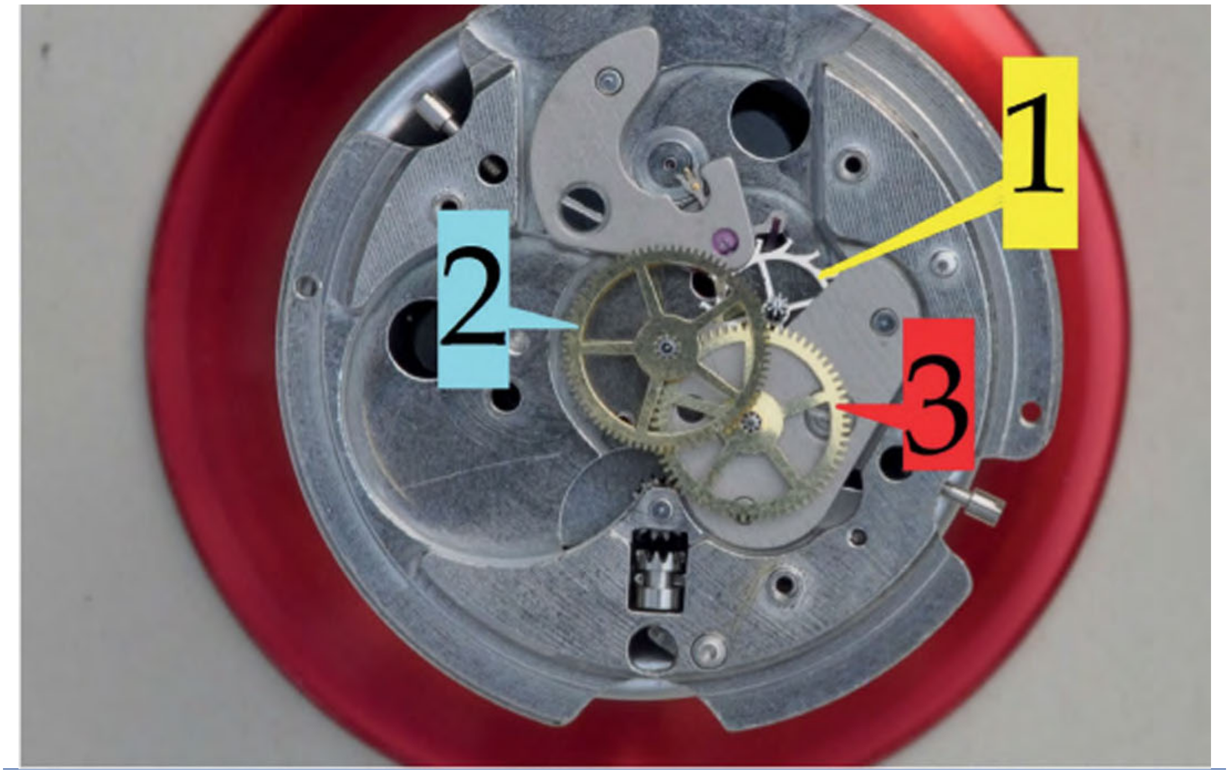


Fig. 294: Direct drive seconds found in a Seiko 7009. (1) Escape wheel. (2) Fourth wheel or centre seconds wheel. (3) Third wheel.

In the picture (Fig. 295) is a Seiko movement with the top plate removed to show a classic direct drive. The centre wheel has been turned upside-down and is supported with its own bridge. The third wheel's pinion then passes through a hole in the centre wheel's bridge to be driven by it. The fourth wheel (now called the centre seconds wheel) has an extended pivot that passes through centre wheel, so that the seconds hand can be fitted. The centre seconds wheel then drives the escape wheel, and so on.

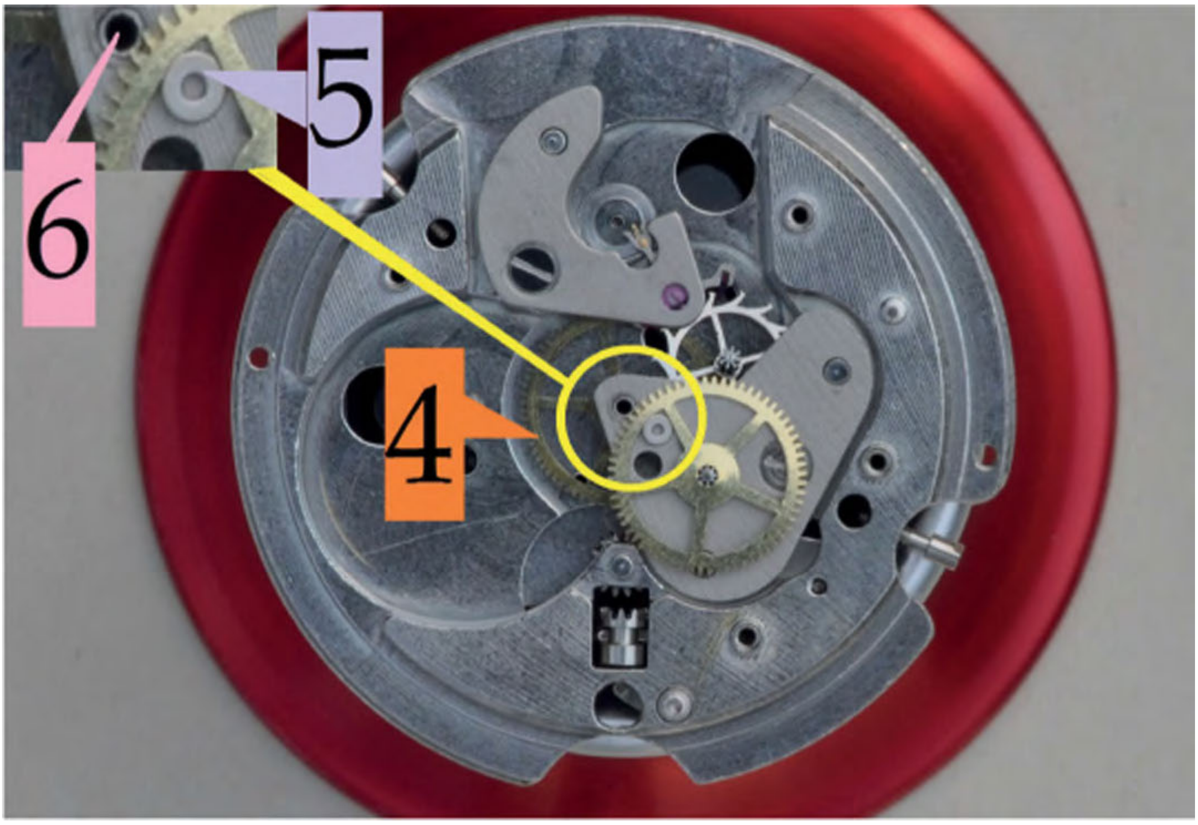


Fig. 295: Seiko 7009 with the centre seconds wheel removed. (4) Centre wheel. (5) Support washer for the centre seconds wheel (not shown in its correct position). (6) Hole in the centre wheel through which the centre seconds extended pivot passes so that the seconds hand can push on to it.

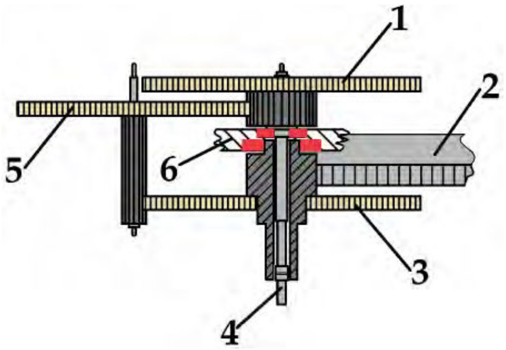


Diagram 42: Side view and section of a direct drive (Seiko style): (1) Centre seconds wheel. (2) Barrel. (3) Centre wheel. (4) Centre seconds wheel extended pivot. (5) Third wheel. (6) Centre wheel bridge.

FURTHER INFORMATION

RECOMMENDED MATERIAL AND TOOL SUPPLIERS

Gleaves: www.gleaveandco.com

COUSINS: WWW.COUSINSUK.COM

H. S.Walsh: www.hswalsh.com

Walkers electronics: www.walkerelectronics.co.uk

Otto Frei: www.tztoolshop.com

International Products Corporation:

www.ipcol.com/ (micro-90 Great for cleaning watch cases)

EDUCATION

British Horological Institute: www.bhi.co.uk

Brigham University: www.bcu.ac.uk/courses/horology-ba

British School of Watchmaking: www.britishschoolofwatchmaking.co.uk

Epping Forest Horology Centre: www.efhc.org.uk

George Daniels Education Trust: www.gdetac.org

Wostep: www.wostep.ch

Nicolas G. Hayek Watchmaking School: www.nghayekwatchmakingschool.com

HOROLOGICAL BODIES

The Clock and Watchmakers' Guild: www.bwcmg.org

Horological Antiquarian Society: www.ahsoc.org

British Horological Institute: www.bhi.co.uk

The Worshipful Company of Clockmakers: www.clockmakers.org

OMEGA WATCH REPAIRS

Antique and Modern: www.clock-watches.co.uk

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